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**SPECTRAL STUDIES OF REFLECTED
SOLAR ENERGY FIELDS, RED TIDE,
KELP 0.68 TO 2.4 MICRONS
C-47 AIRCRAFT**

W. A. HOVIS

NOVEMBER 1968



GODDARD SPACE FLIGHT CENTER

GREENBELT, MARYLAND

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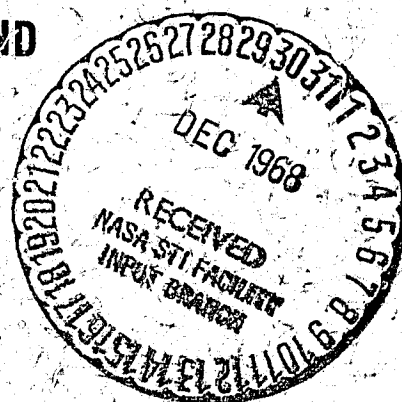
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FACILITY FORM 602



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RED TIDE, Kelp 0.68 TO 2.4 MICRONS

C-47 AIRCRAFT

W. A. Hovis

November 1968

**GODDARD SPACE FLIGHT CENTER
Greenbelt, Maryland**

SPECTRAL STUDIES OF REFLECTED SOLAR ENERGY FIELDS, RED TIDE, KELP 0.68 TO 2.4 MICRONS C-47 AIRCRAFT

I. INTRODUCTION

As part of a program to determine the spectral distribution of reflected solar energy from natural surfaces measurements were made, over a variety of surfaces, with a down-looking spectrometer mounted in a C-47 aircraft. Of particular interest was the magnitude of energy reflected from vegetation, both marine and terrestrial, in the spectral interval 0.7 to 1.3 microns. It is well known that chlorophyll-bearing vegetation has a strong reflectance feature in that spectral interval, and since the Nimbus B-2 High Resolution Infrared Radiometer has a channel responding to radiation in the interval from 0.7 to 1.3 microns the question arose as to what degree fields of green vegetation might be confused with clouds, also a strong reflector from 0.7 to 1.3 microns.

A previous flight, on the NASA Convair 990 jet aircraft, over the Yucatan Jungle of Mexico showed that jungles were rather poor reflectors, but the question of cultivated fields and marine vegetation remained unanswered. The data presented here do not, of course, present a complete answer, but they at least allow the magnitude of the problem to be estimated.

II. INSTRUMENTATION AND VEHICLE

The spectrometer used was a filter wedge spectrometer of the type described by Hovis, Kley and Strange (1). The instrument used two filter halves for the total coverage of 0.68 to 2.4 microns with a spectral resolving power ($\lambda/\Delta\lambda$) of 100 at the short wavelength end and slightly better, about 114, in the longer wavelength portion of the spectrum. The detector used was uncooled lead sulfide with a total scanning time of 12 seconds for the 0.68 to 2.4 micron interval. The instantaneous field of view was 0.02×0.10 radians with the long dimension perpendicular to the direction of flight.

The aircraft utilized was a C-47, NASA 636, piloted by Byron Batthauer and crewed by George Ford, both of NASA's Lewis Research Center. During data flight the plane was flown straight and level at the altitudes indicated for particular flights and at a velocity of approximately 100 knots.

III. SAN JOAQUIN VALLEY

On May 23, 1968 the aircraft left San Jose Municipal Airport, flew out over the Pacific at Monterey Bay, along the edge of Monterey Bay and inland at Big Sur. Spectra were taken over the wooded mountains inland from Big Sur. The flight continued to the San Joaquin Valley, and flights were made over fields near Wasco and Bakersfield. The fields are identified in Table 1 as to crop and location. The identification of the crop type was supplied by the local U.S.D.A. office at Shafter.

The time the data were taken is shown in local time, in this case Pacific Daylight Time, on all the spectra. For instance spectra 1 and 2 of this group were started at 10 hrs 23 mins and 49 seconds and 10 hrs 23 mins and 55 seconds respectively.

IV. KELP BEDS AND RED TIDE

On May 26, 1968, a flight was made out of San Diego, California north to the vicinity of Laguna and returning to San Diego. This flight was for the specific purpose of acquiring reflectance measurements over red tide and kelp along the coast. The flight was made at an altitude of 1000 ft and all measurements were made when the plane was flying straight and level. The area and type of target viewed is shown in Table 2.

V. IMPERIAL VALLEY

On May 27, 1968 a flight was made over the Imperial Valley just south of the Salton Sea. The day was hazy and complicated by an inversion layer trapping pollutants from nearby factories. All data were taken while flying straight and level. The flights are described in Table 3.

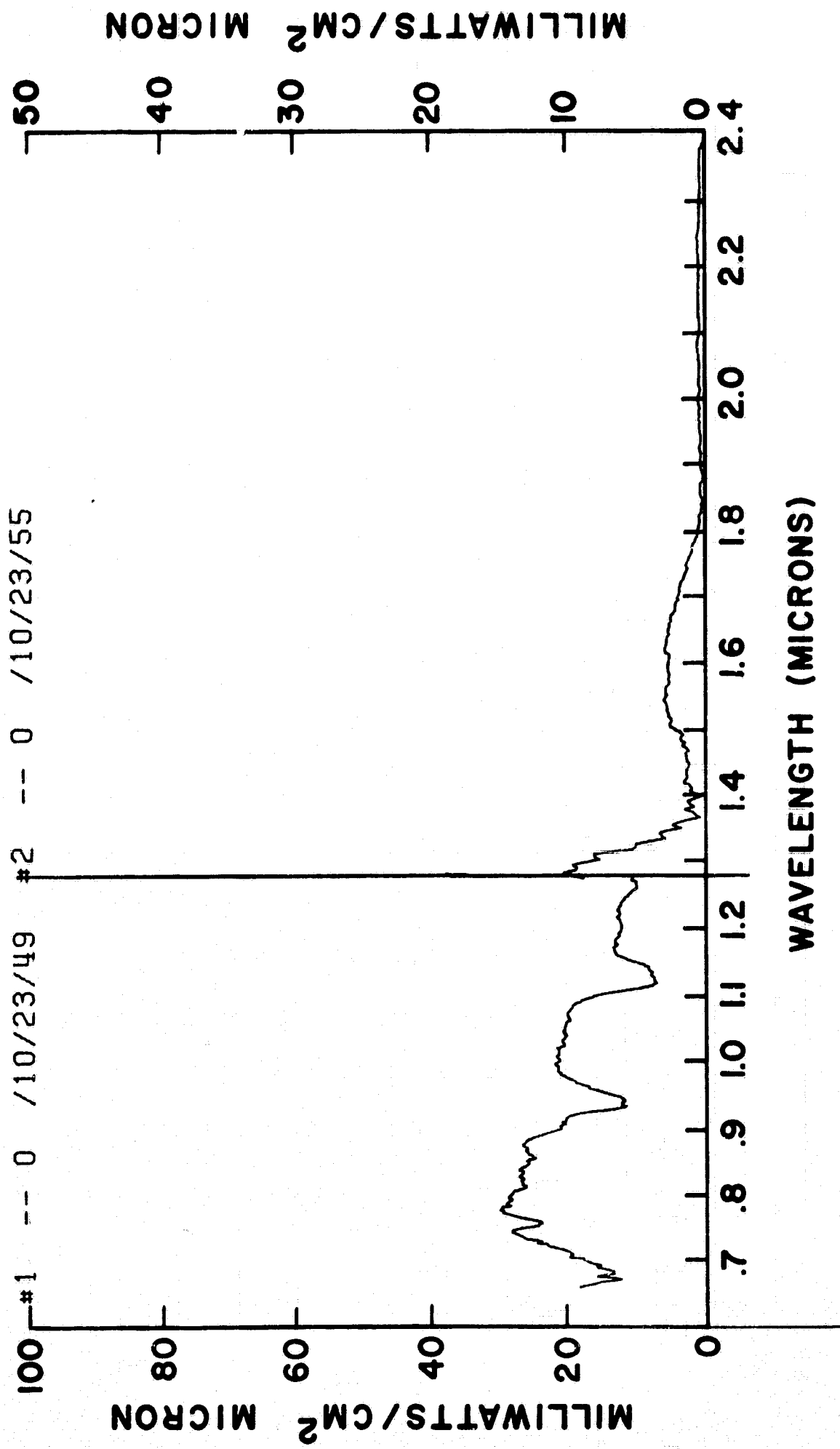
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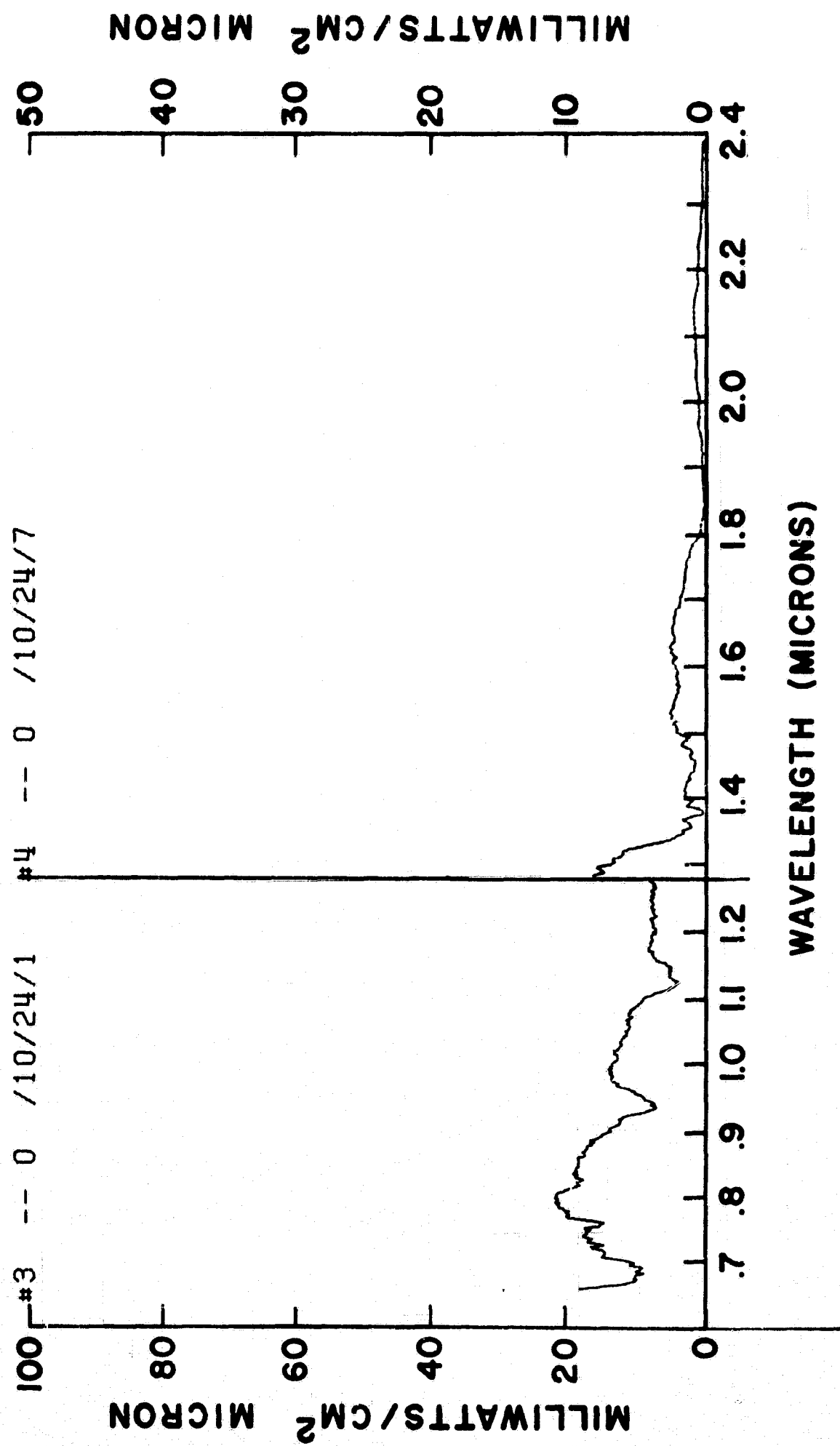
1. W. A. Hovis Jr., W. A. Kley and M. G. Strange, Filter Wedge Spectrometer for Field Use, Applied Optics, 6, 1057, (1967).

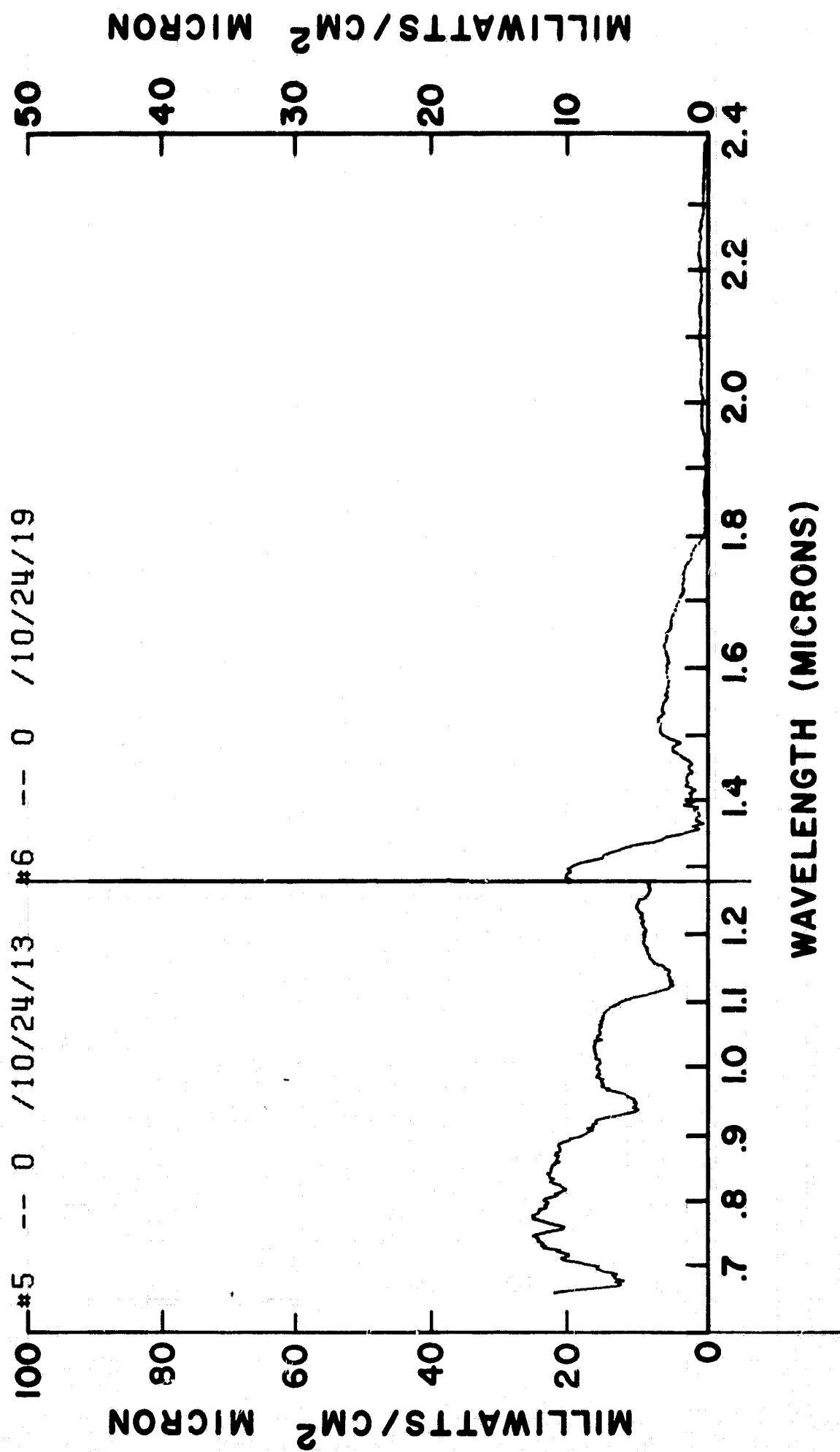
Table 1

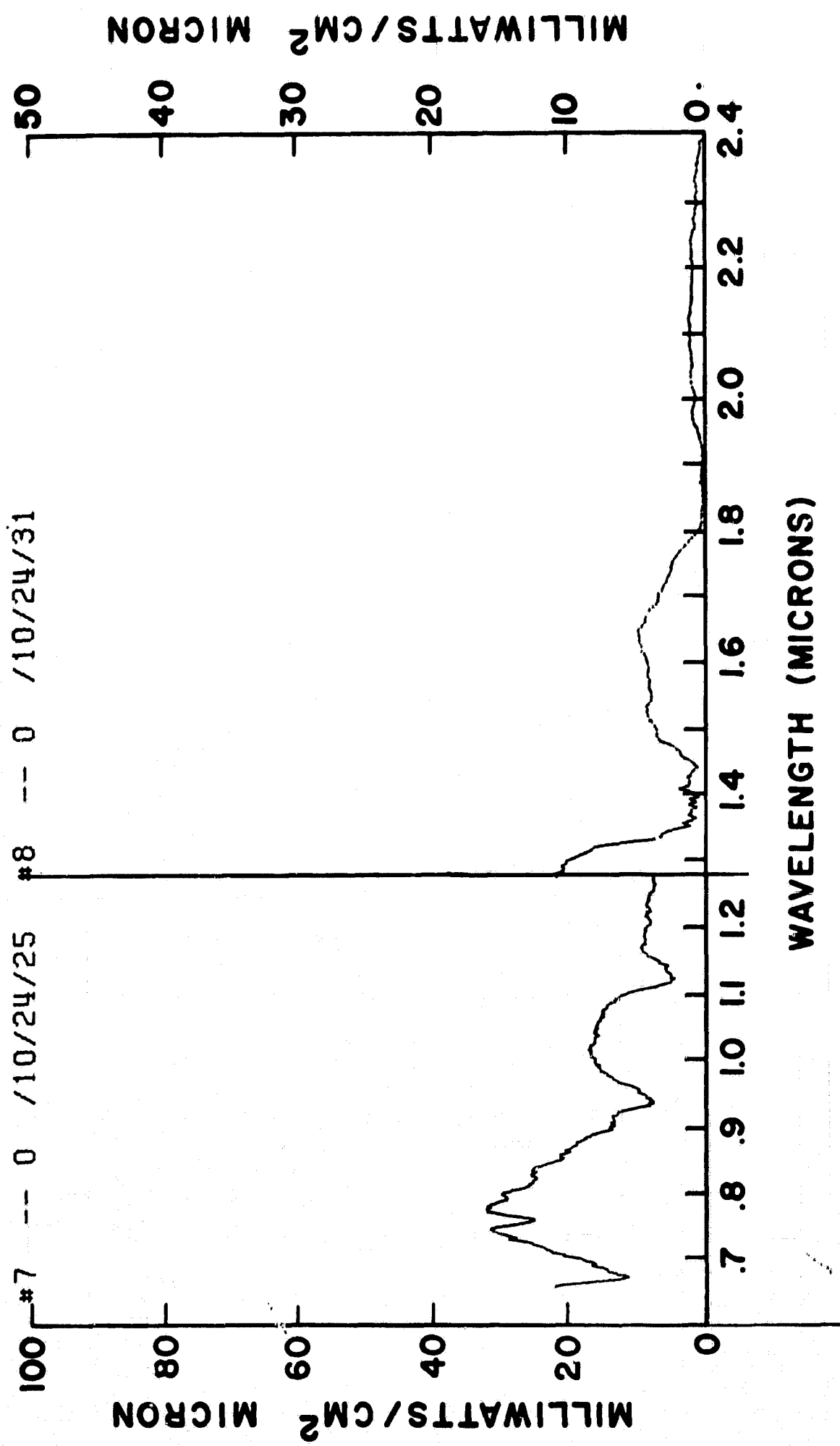
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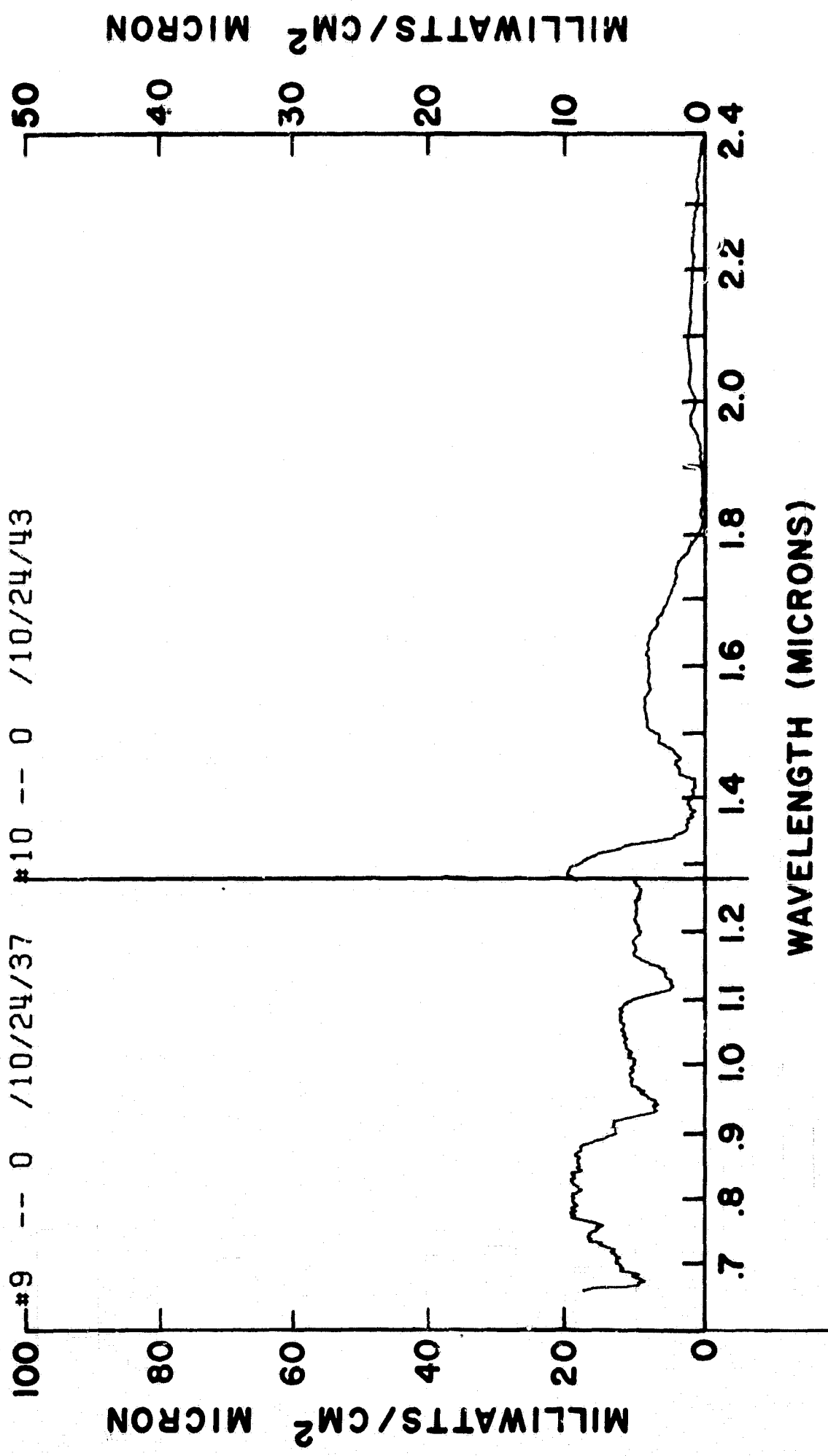
Spectrum Nos. Inclusive	Target	Location	Altitude kft
1-12	Forested Mountains	Inland of Big Sur	7
13-26	Approach to Field #1	35°36', 119°25'	
27-33	Over Field #1 Potatoes	W of Wasco, Calif.	1
34-35	Approach to Field #1		1
36-40	Over Field #1 Potatoes		1
41-44	Approach to Field #2	35°27.5', 119°11' SE of Shafter, Calif.	1
45-50	Over Field #2 Potatoes		
51-54	Approach to Field #3	35°24', 119°6'	
55-58	Over Field #3 Potatoes	W of Bakersfield, Calif.	1
67-68	Approach to Field #3		
69-74	Over Field #3		
75-85	Over Field #4 Cotton	35°09', 118°52' S of Arvin, Calif.	1
86-87	Approach to Field #5	35°11', 118°55'	1
88-95	Over Field #5 Cotton	WSW of Arvin, Calif.	1

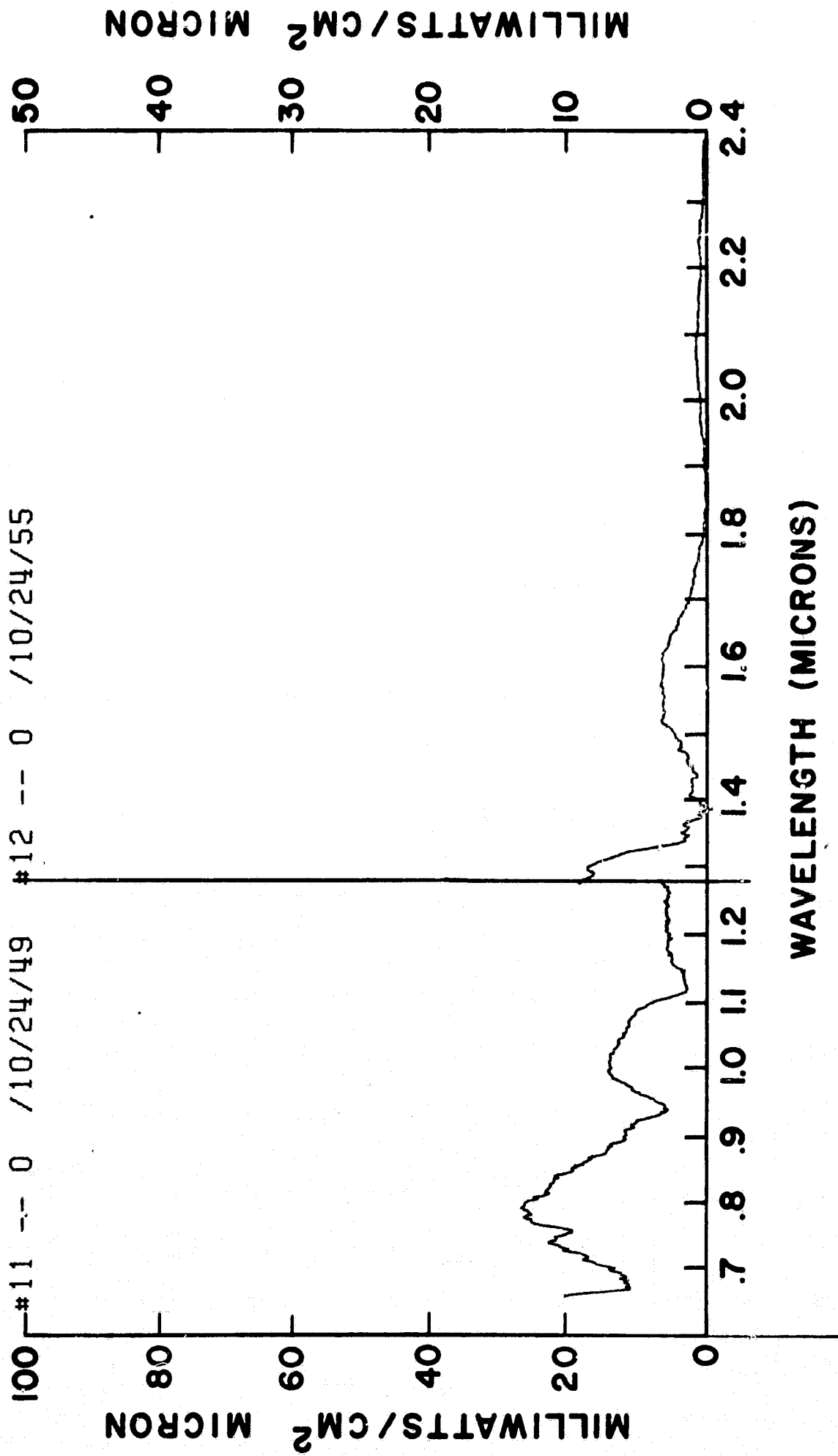


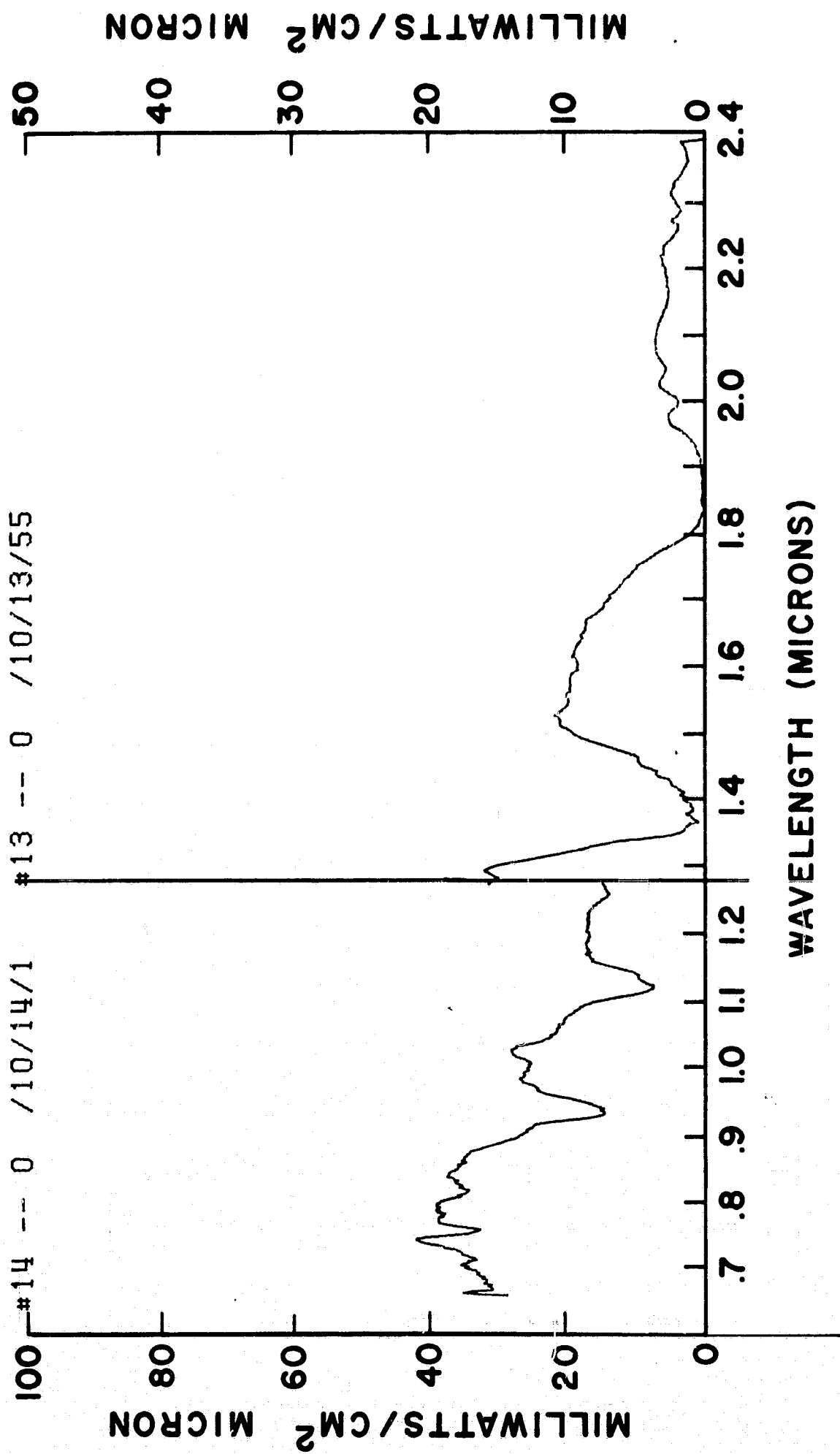


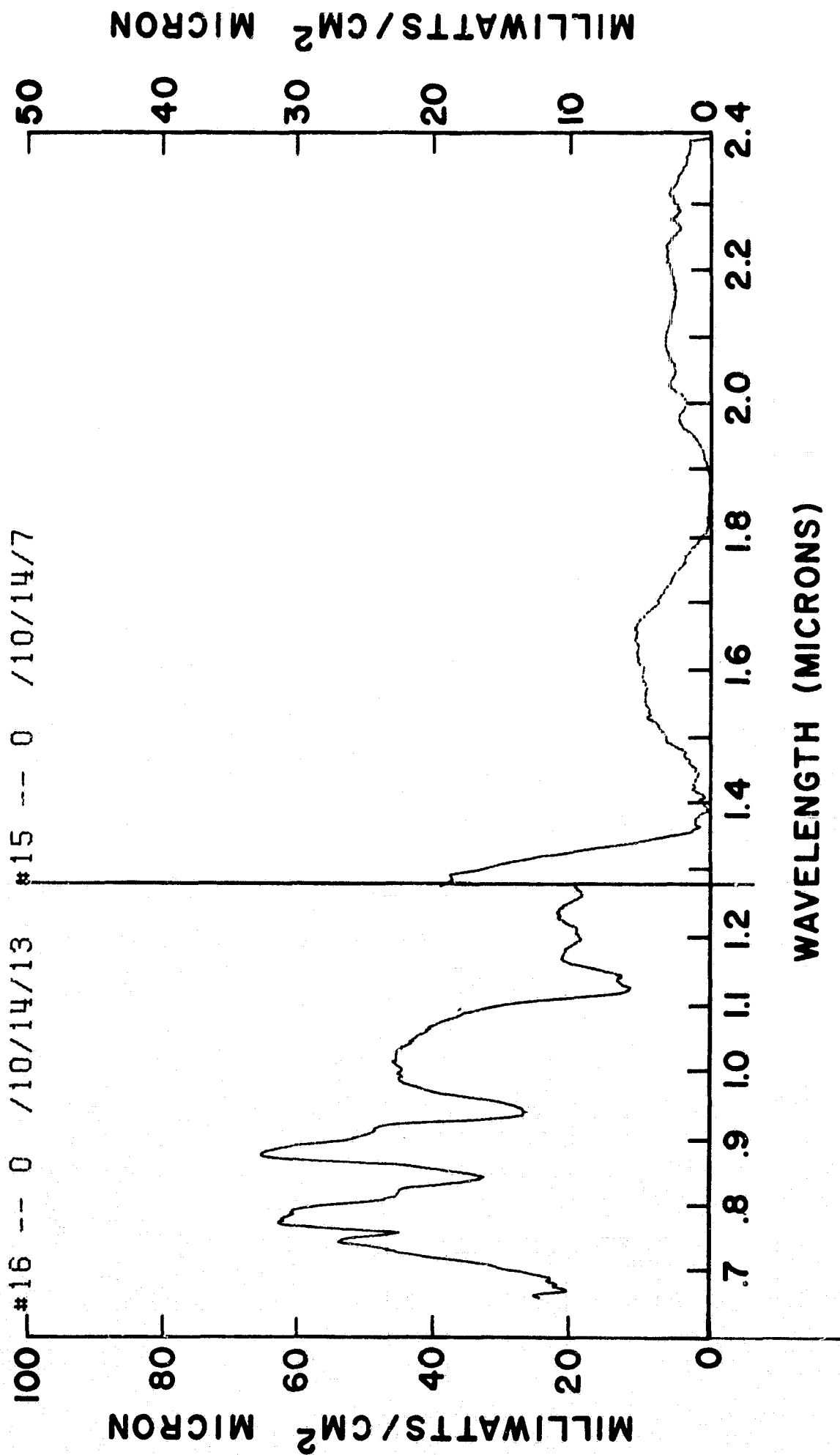


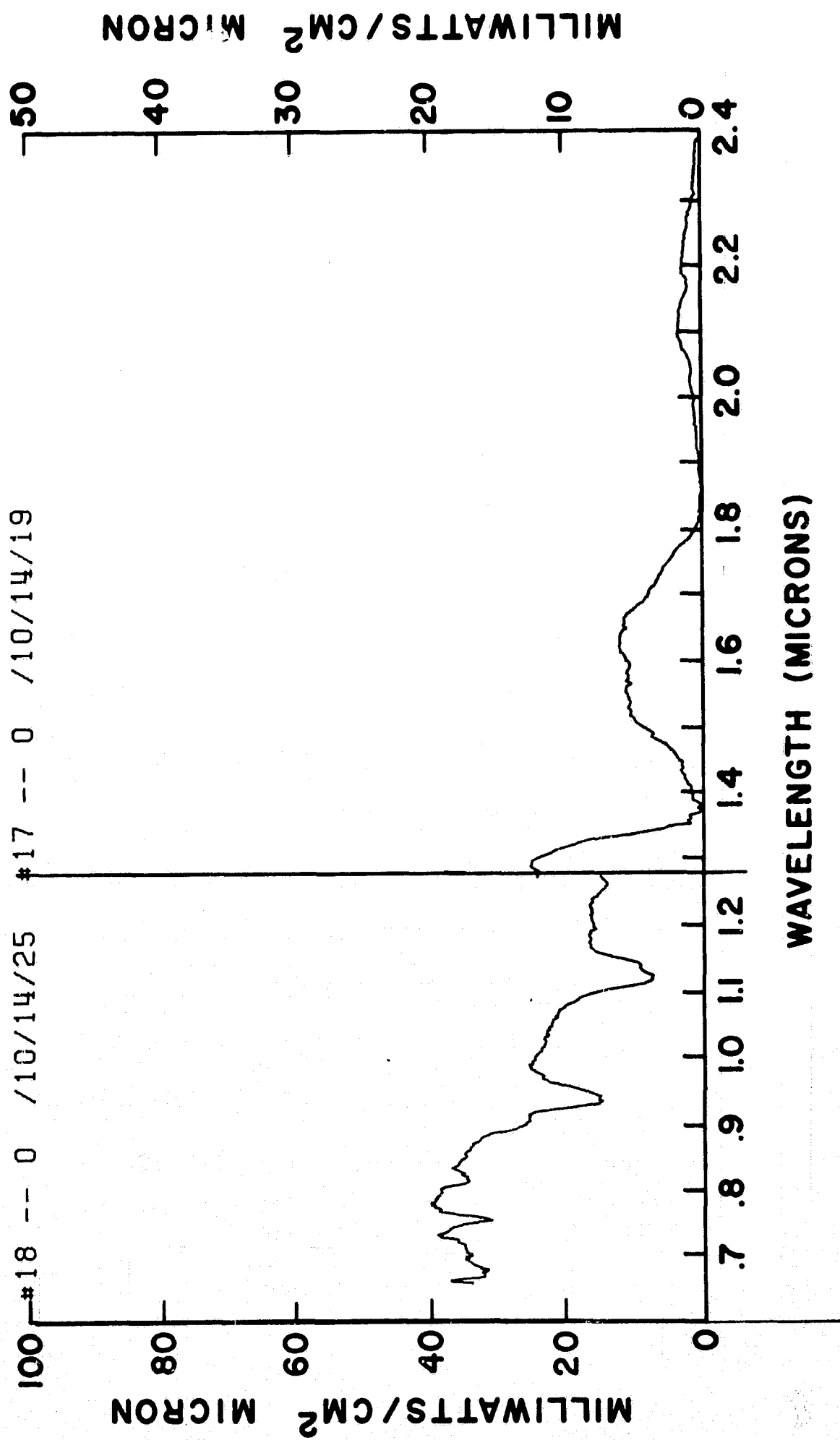


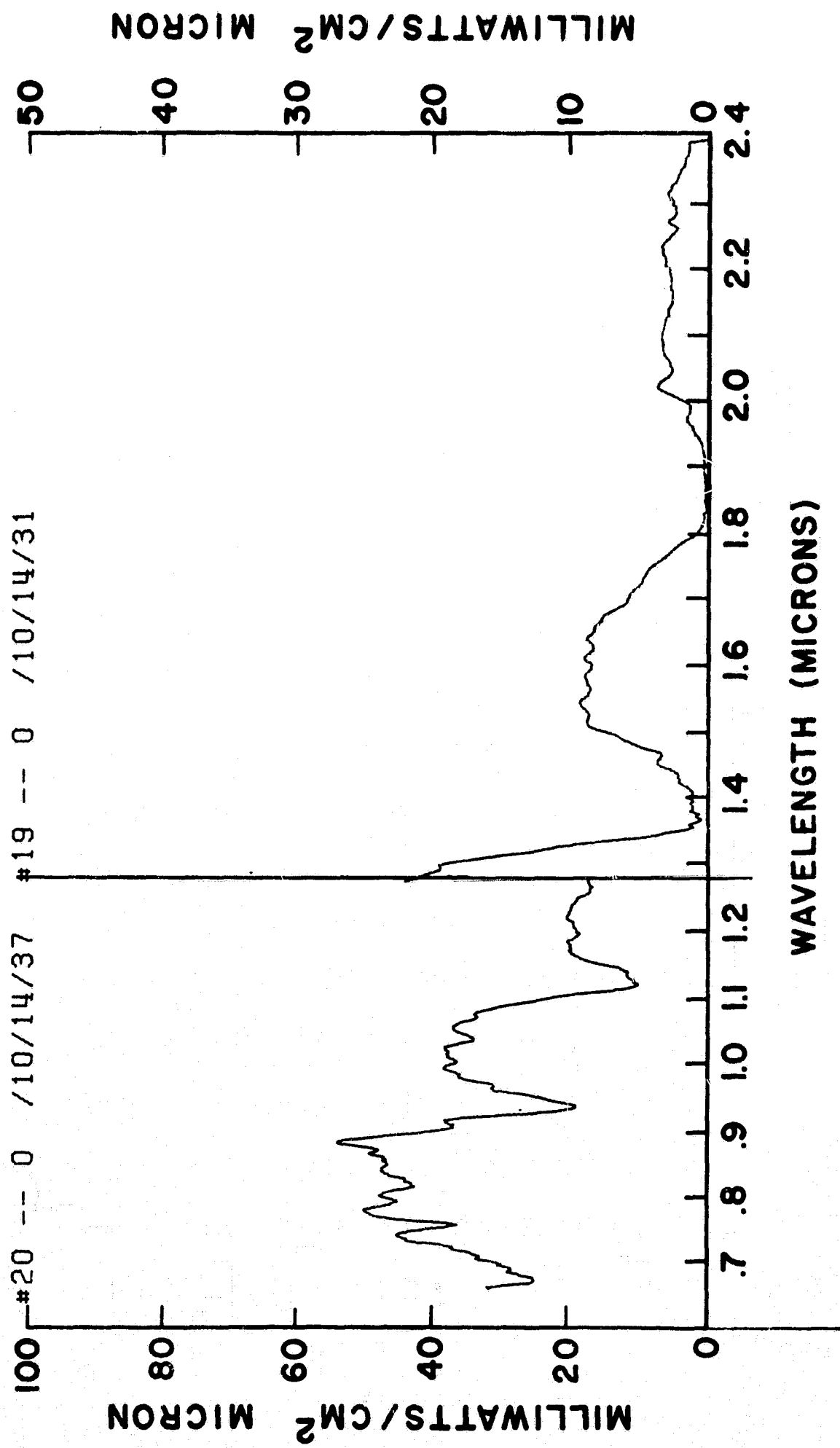


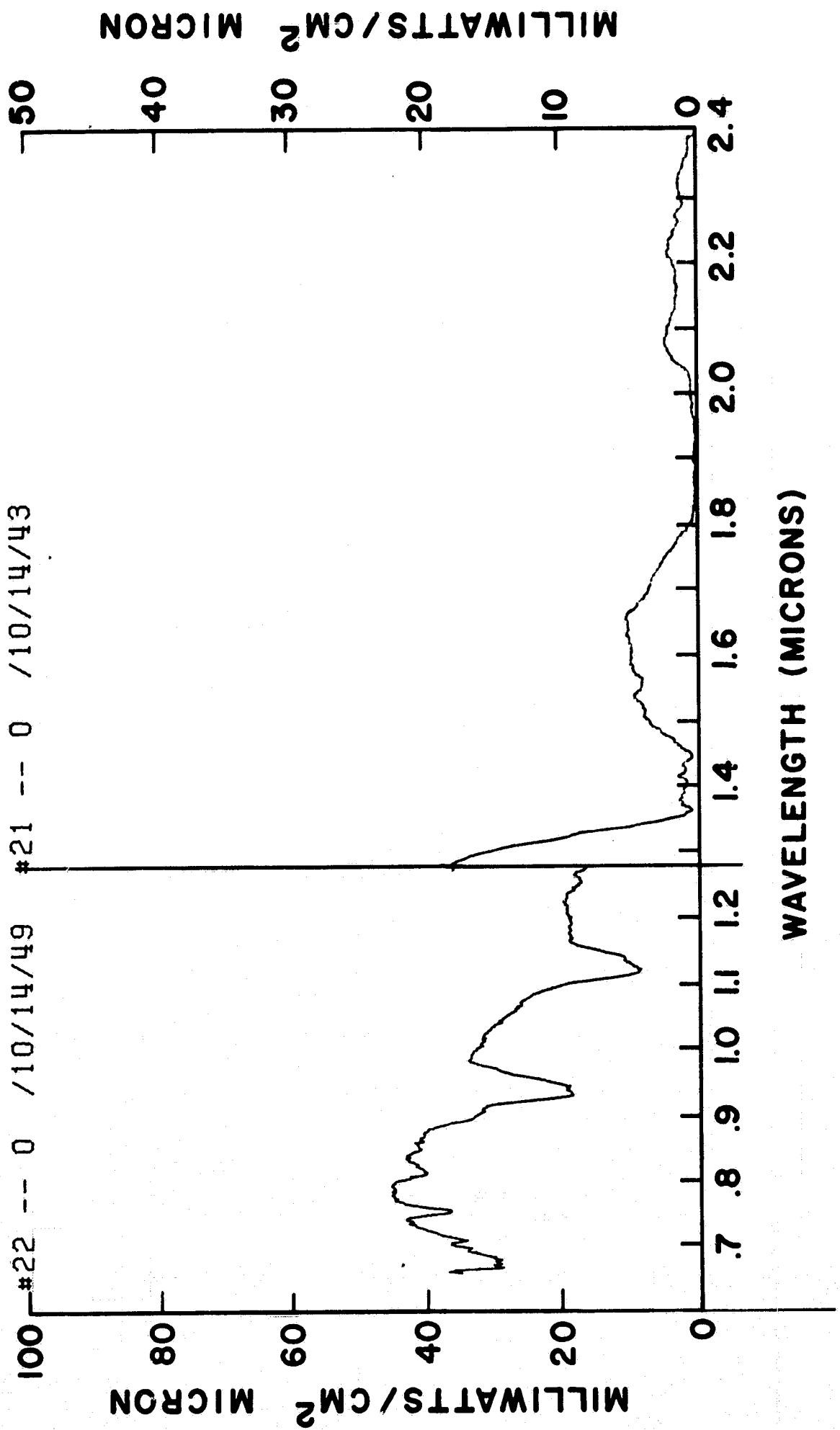


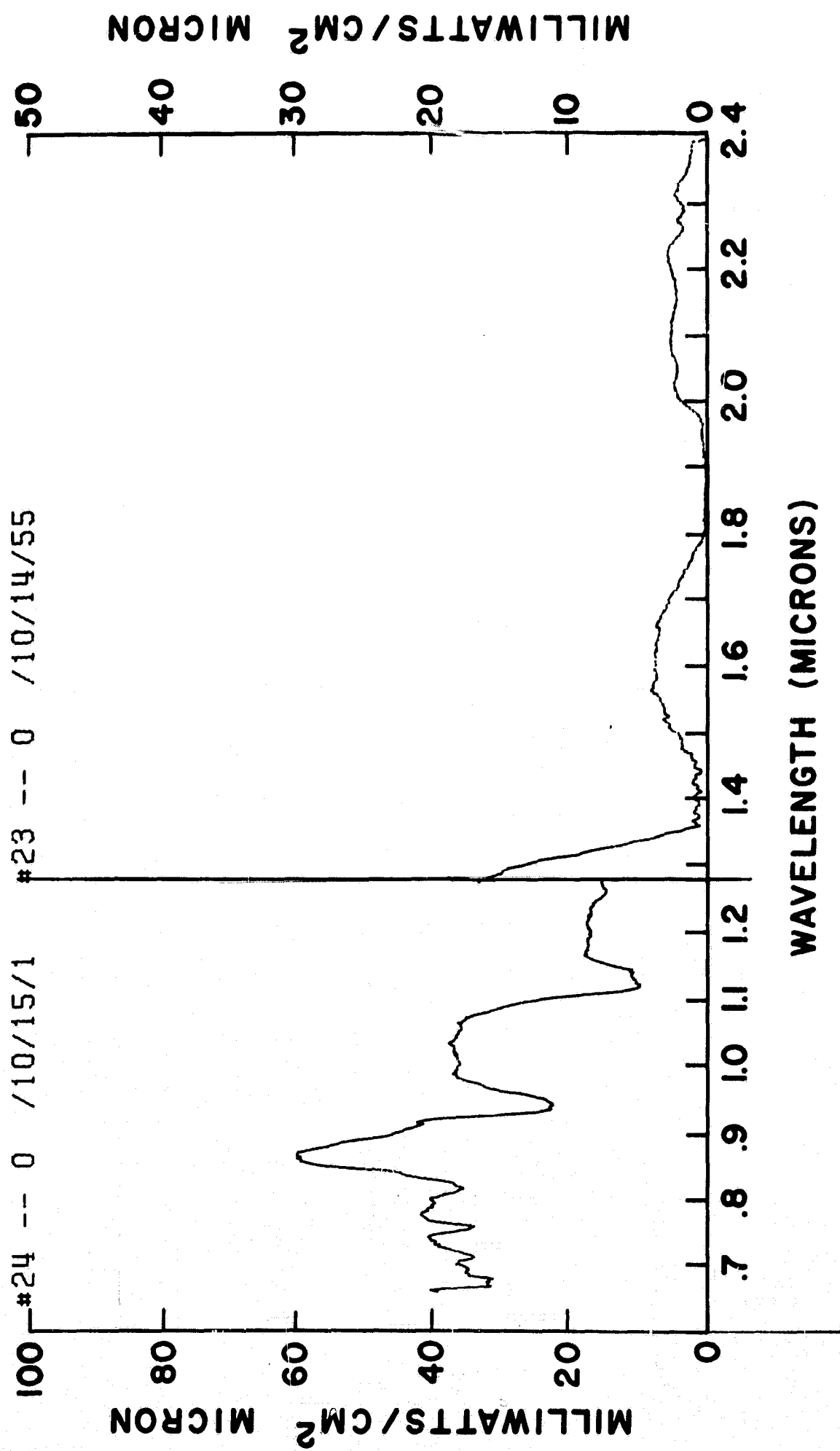


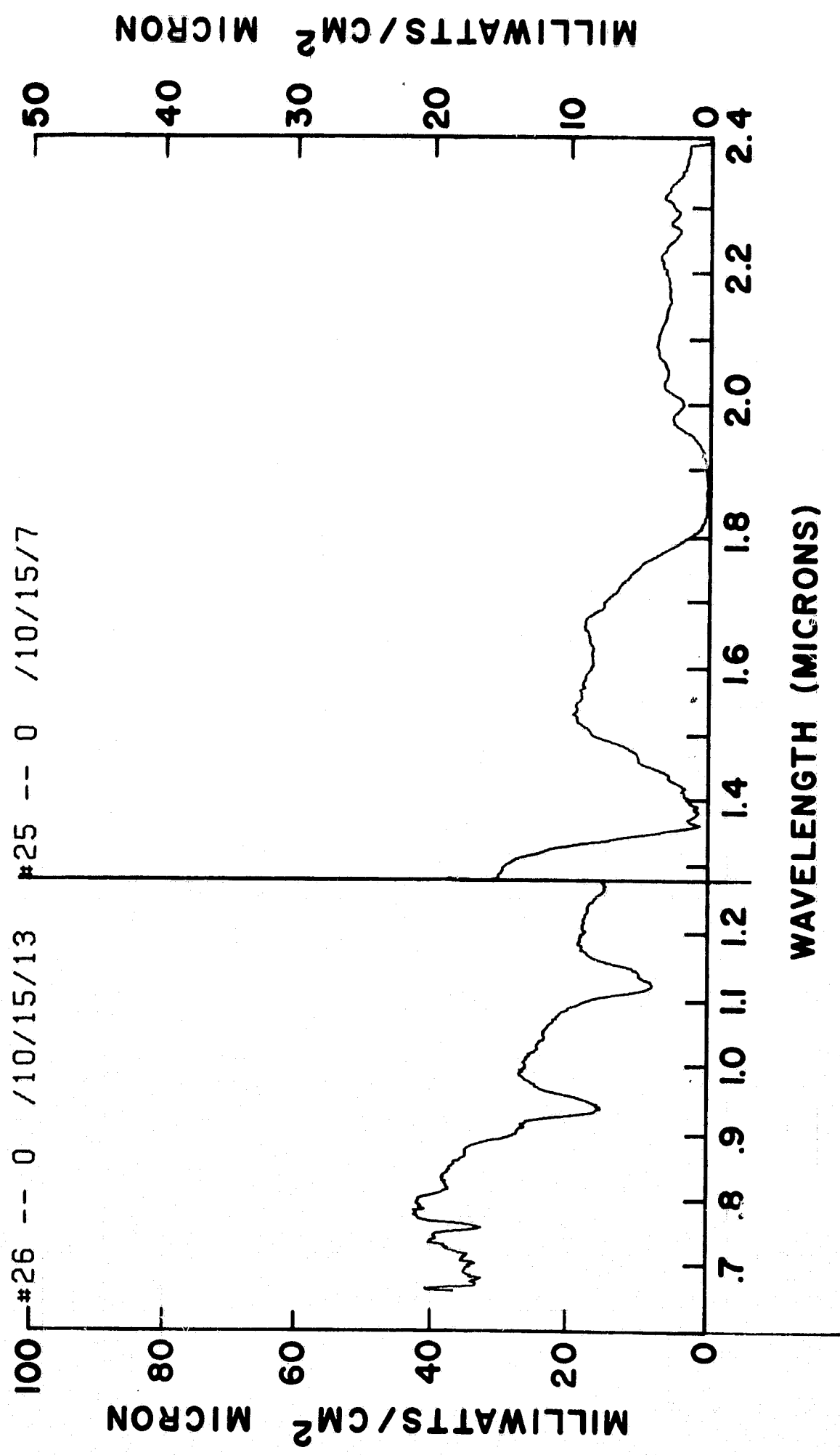


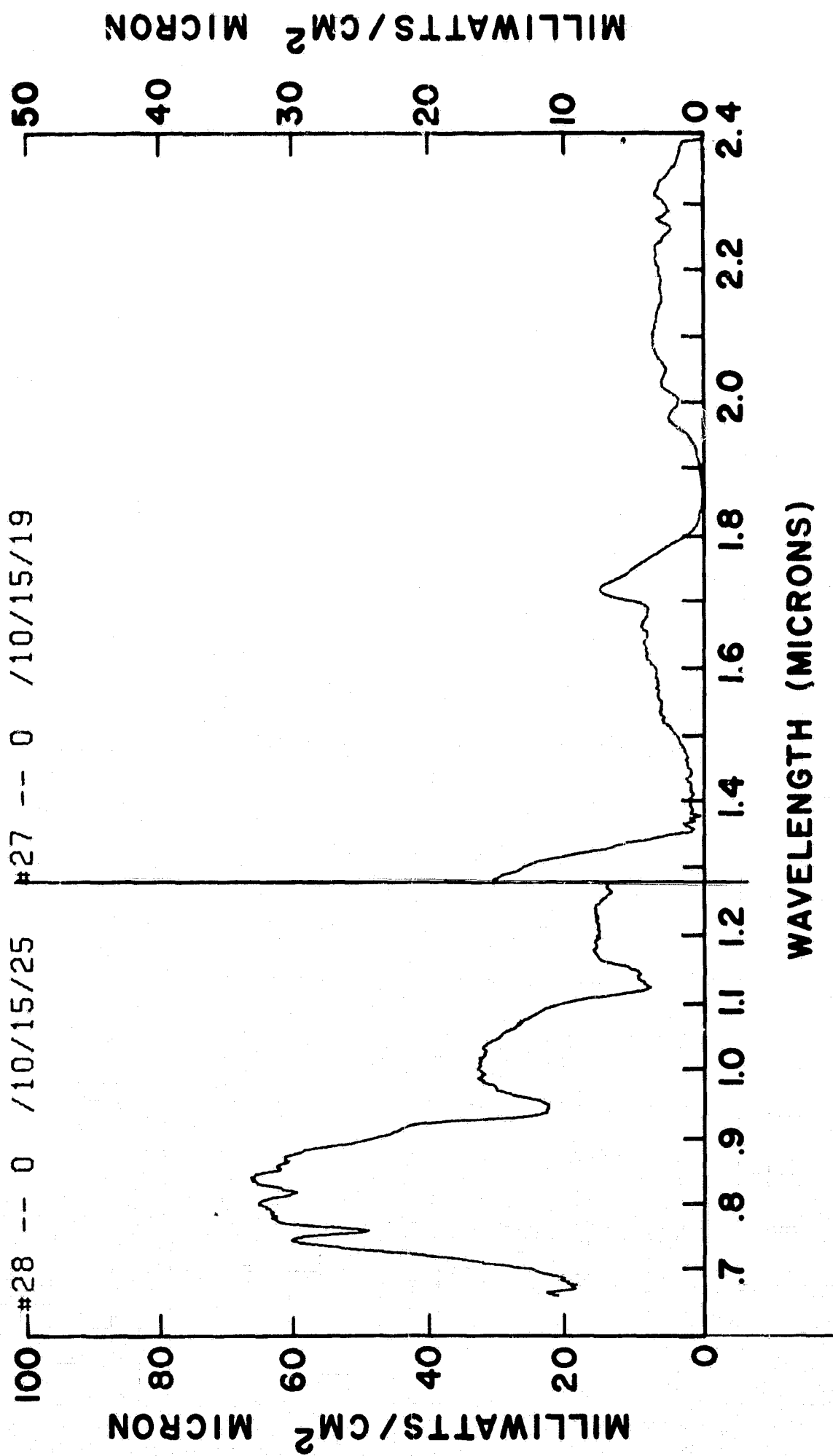


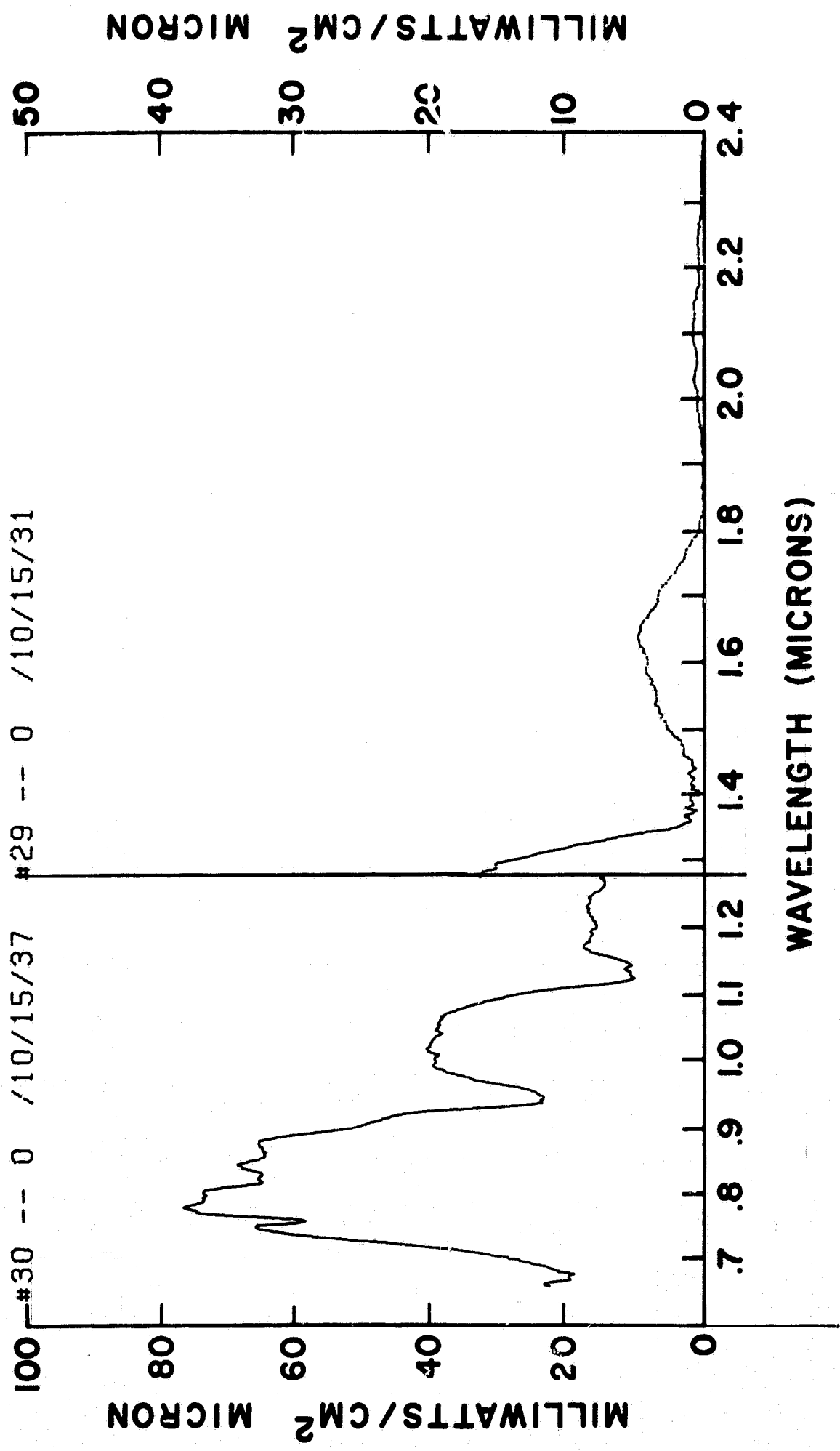


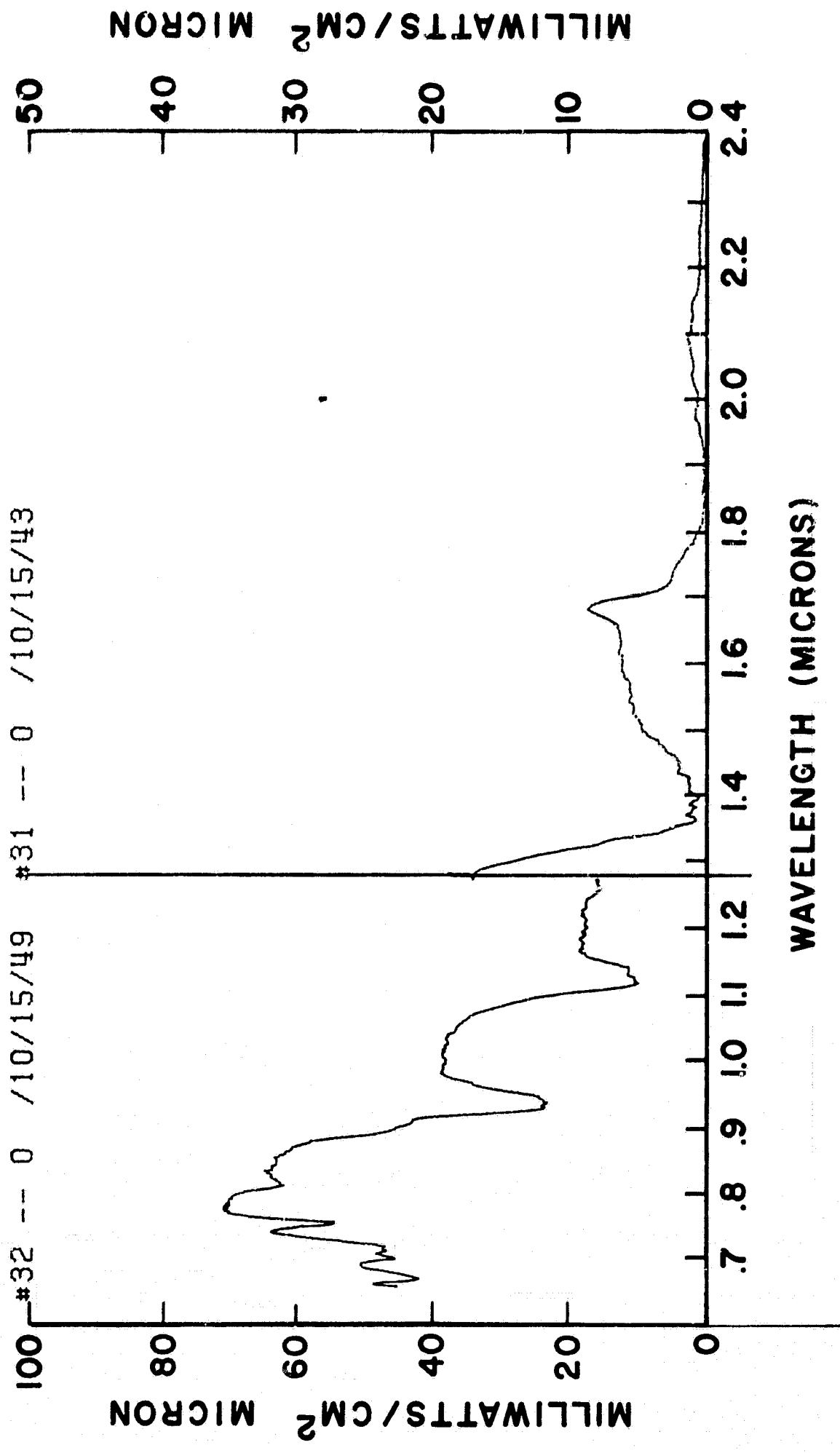


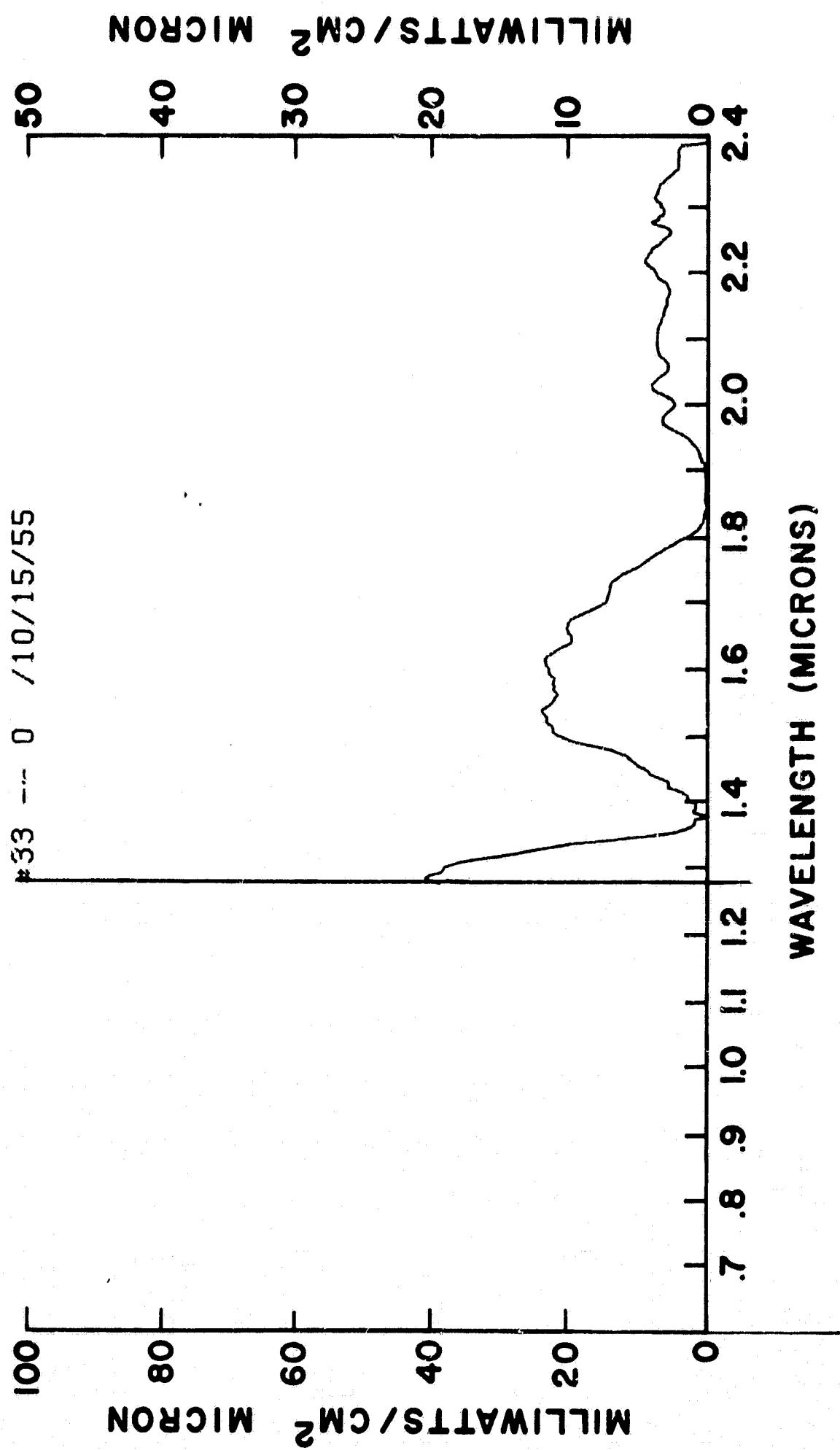


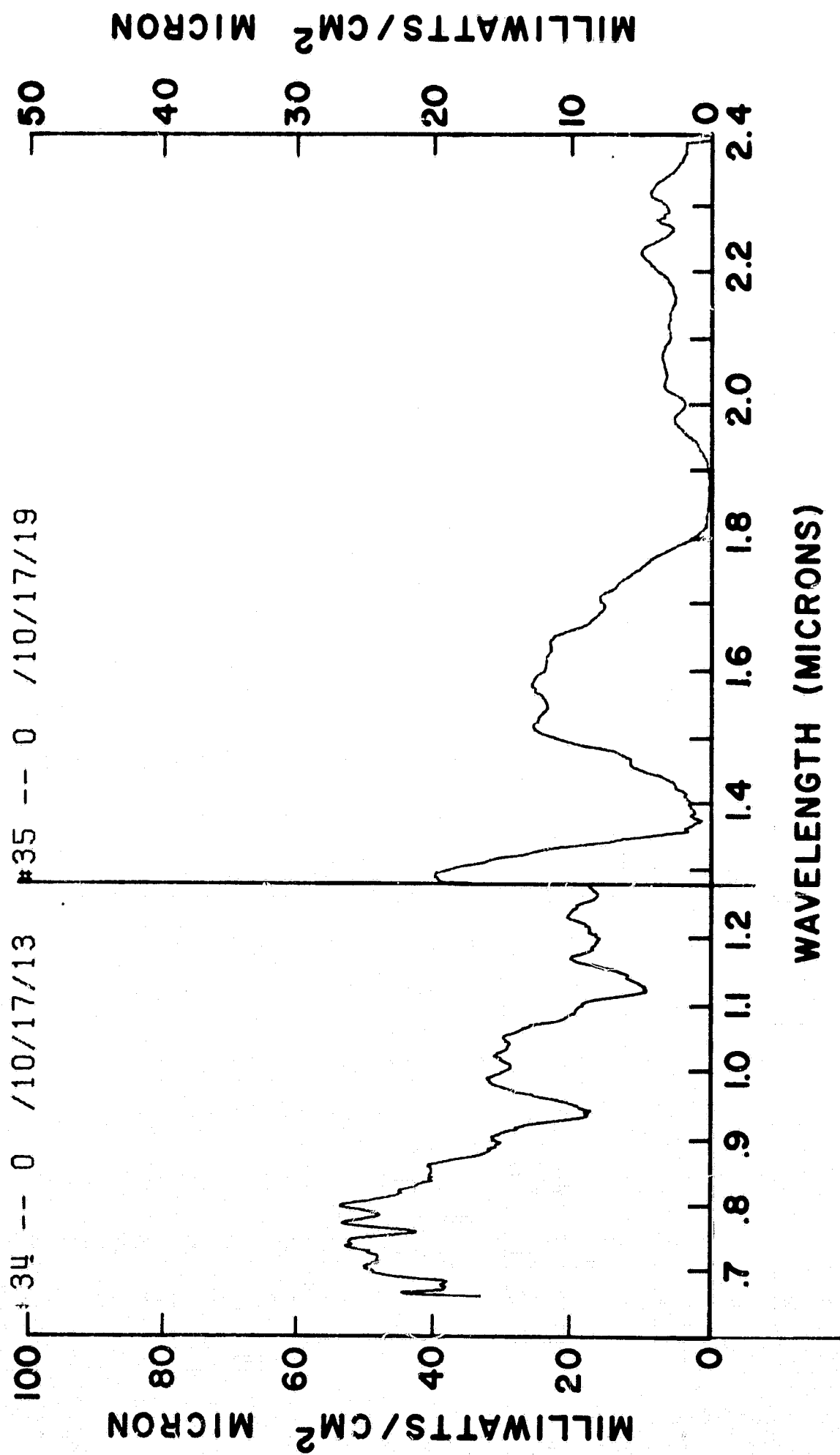


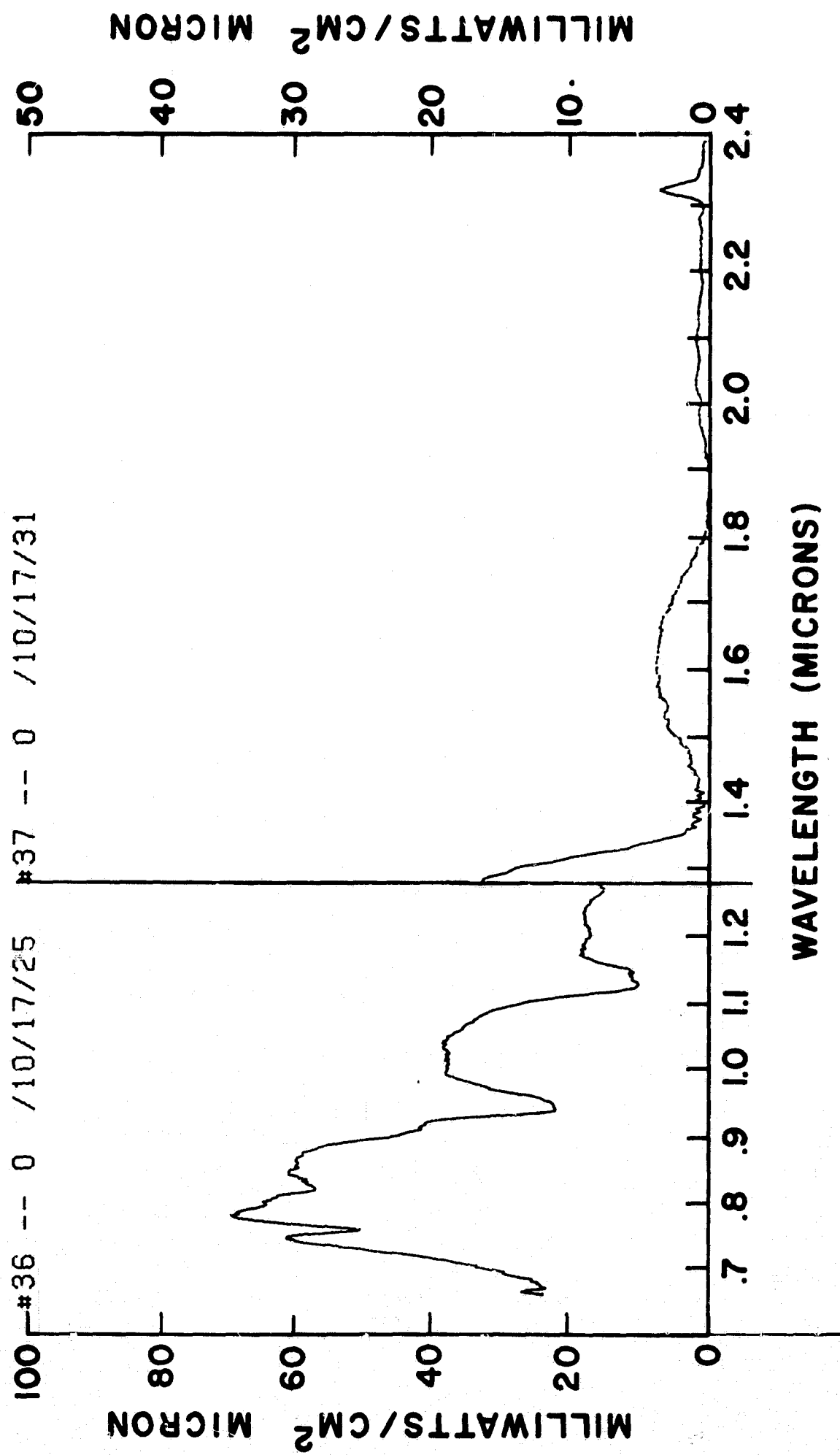


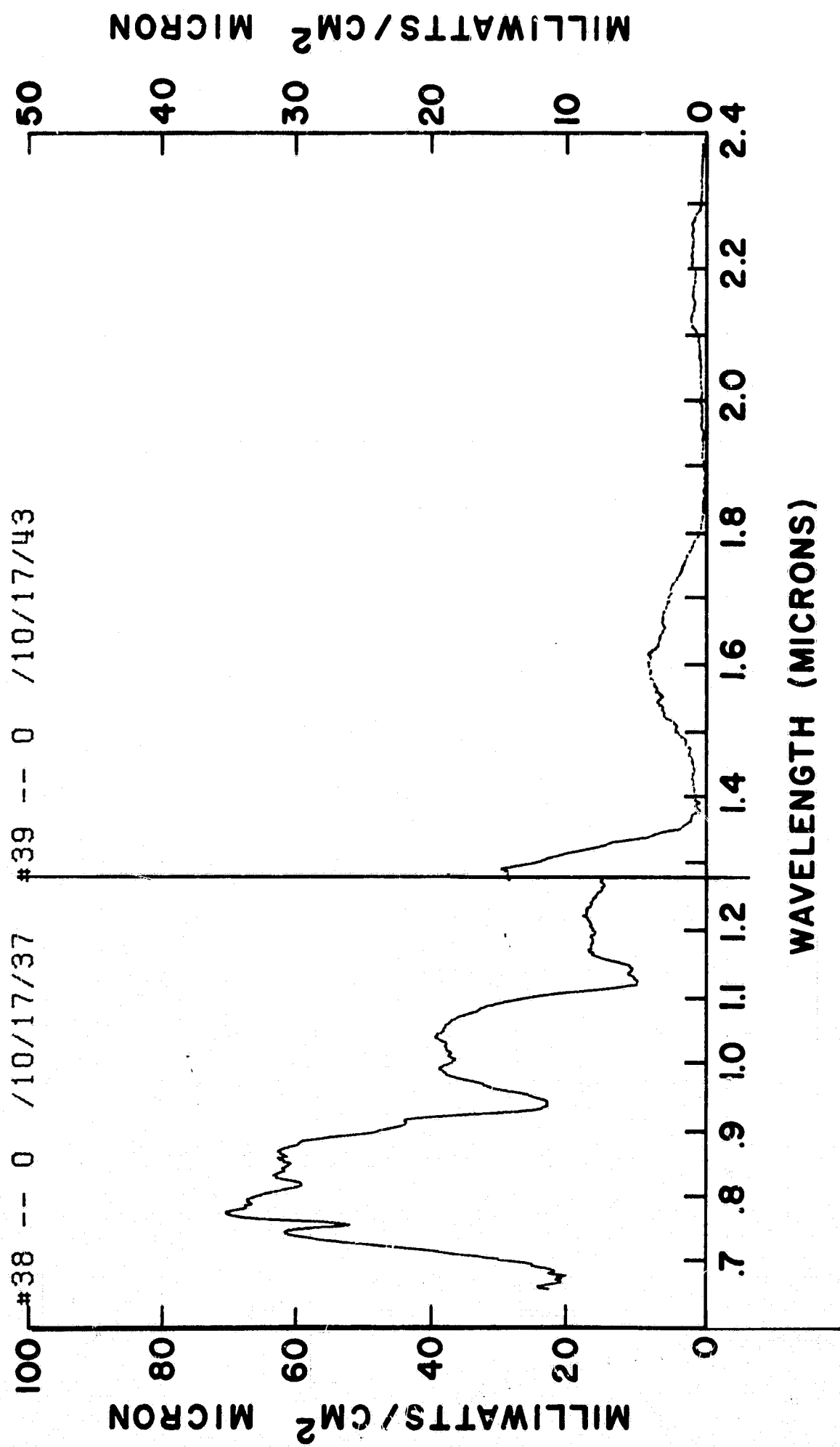


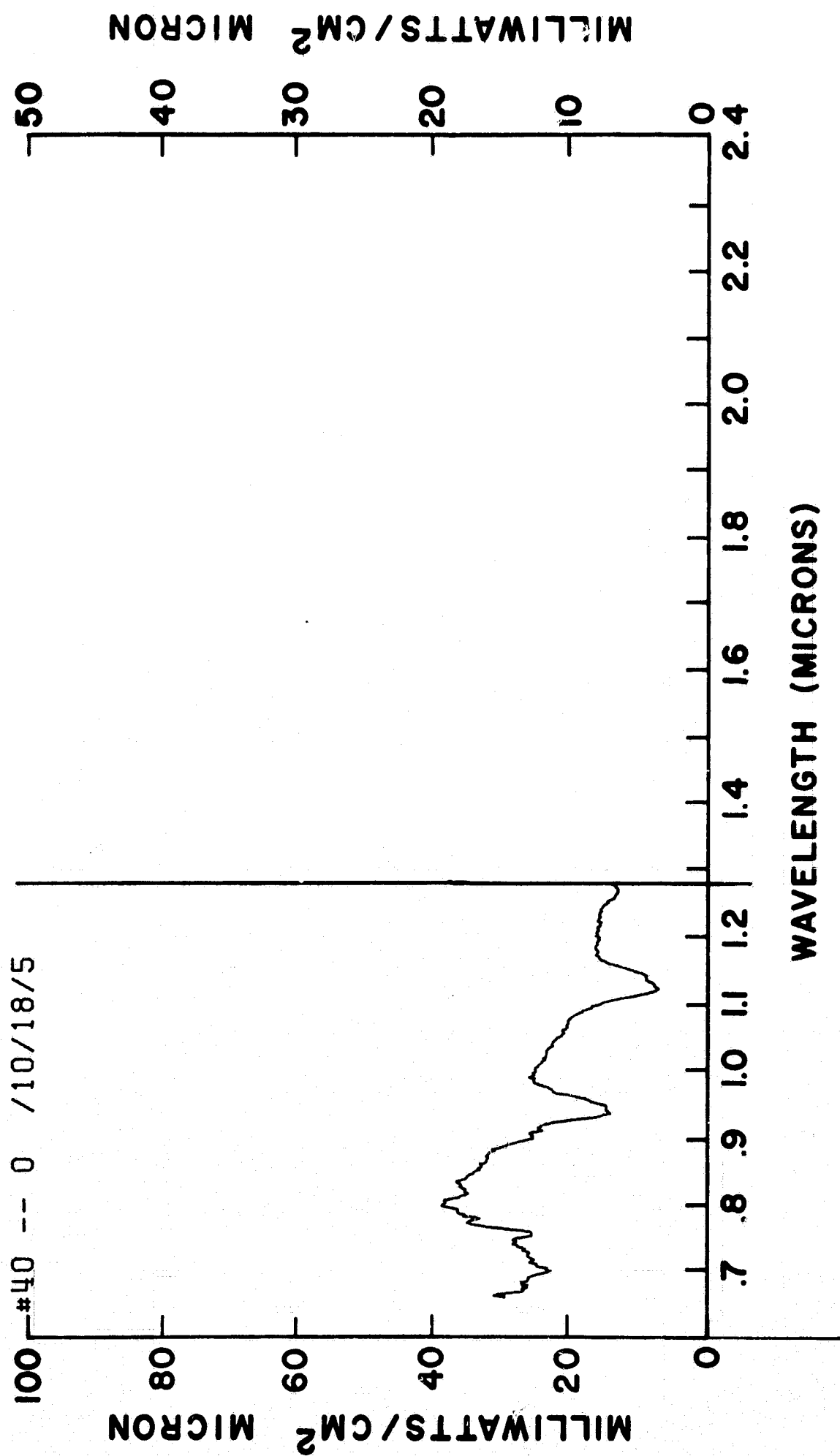


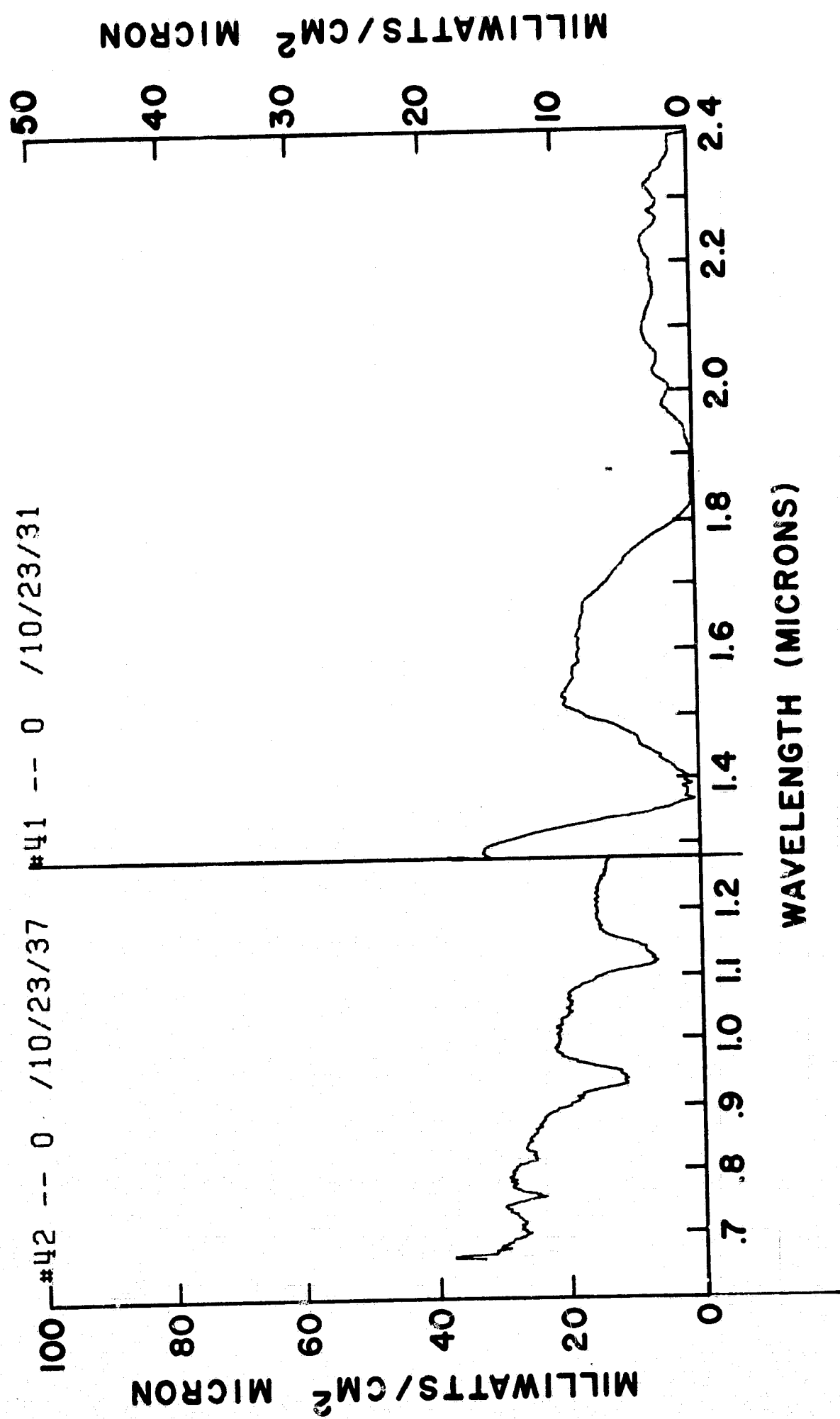


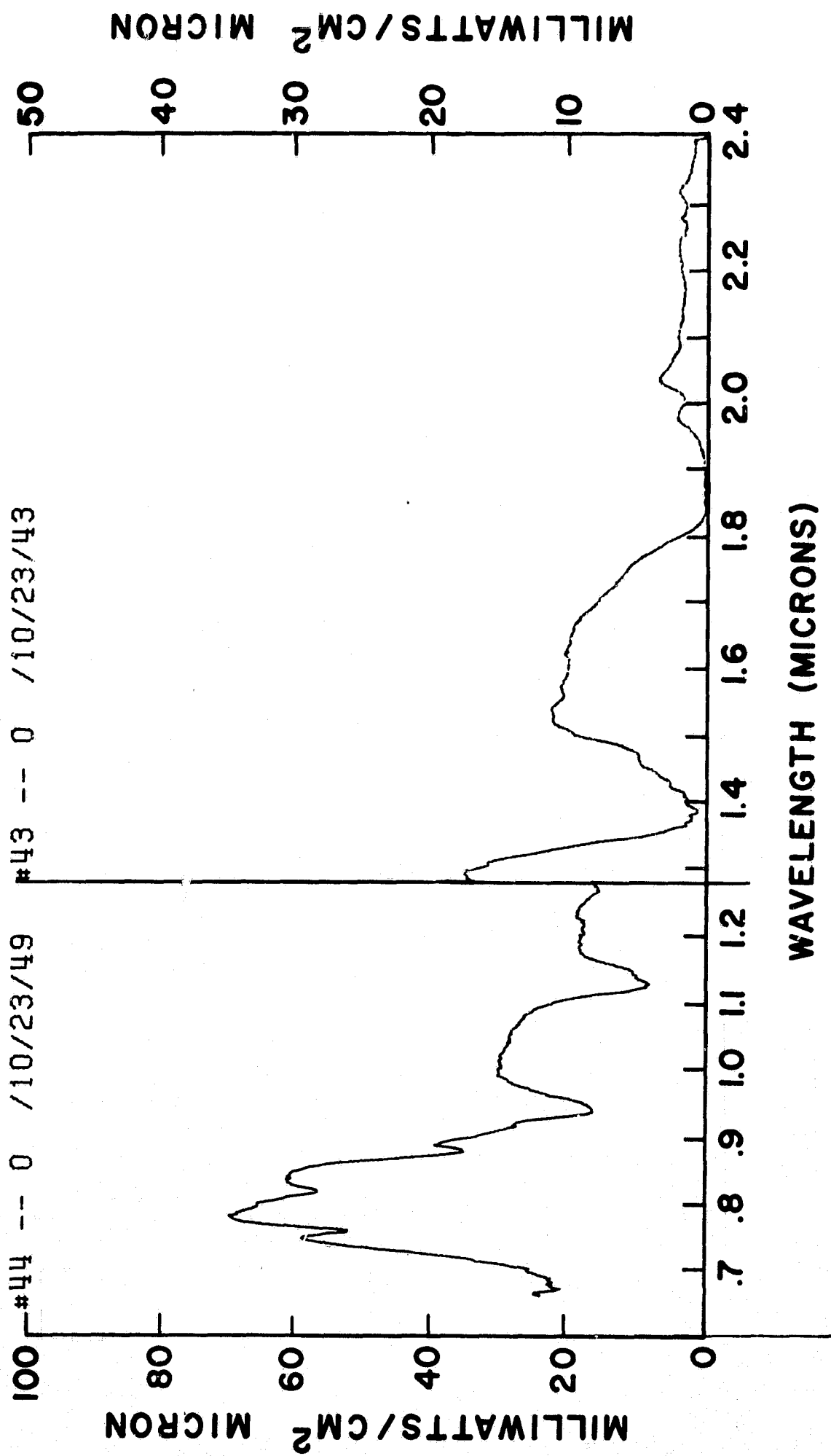


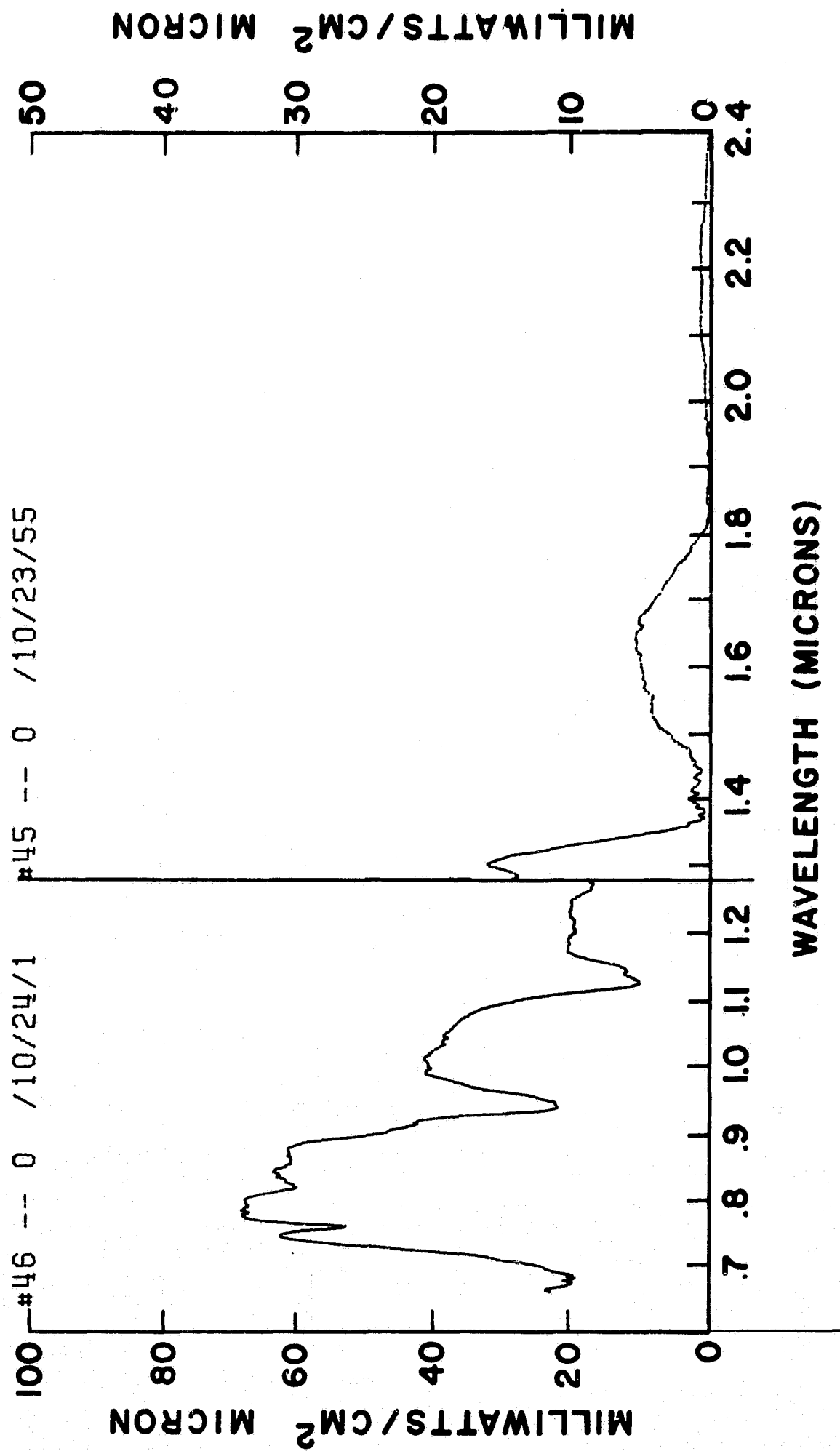


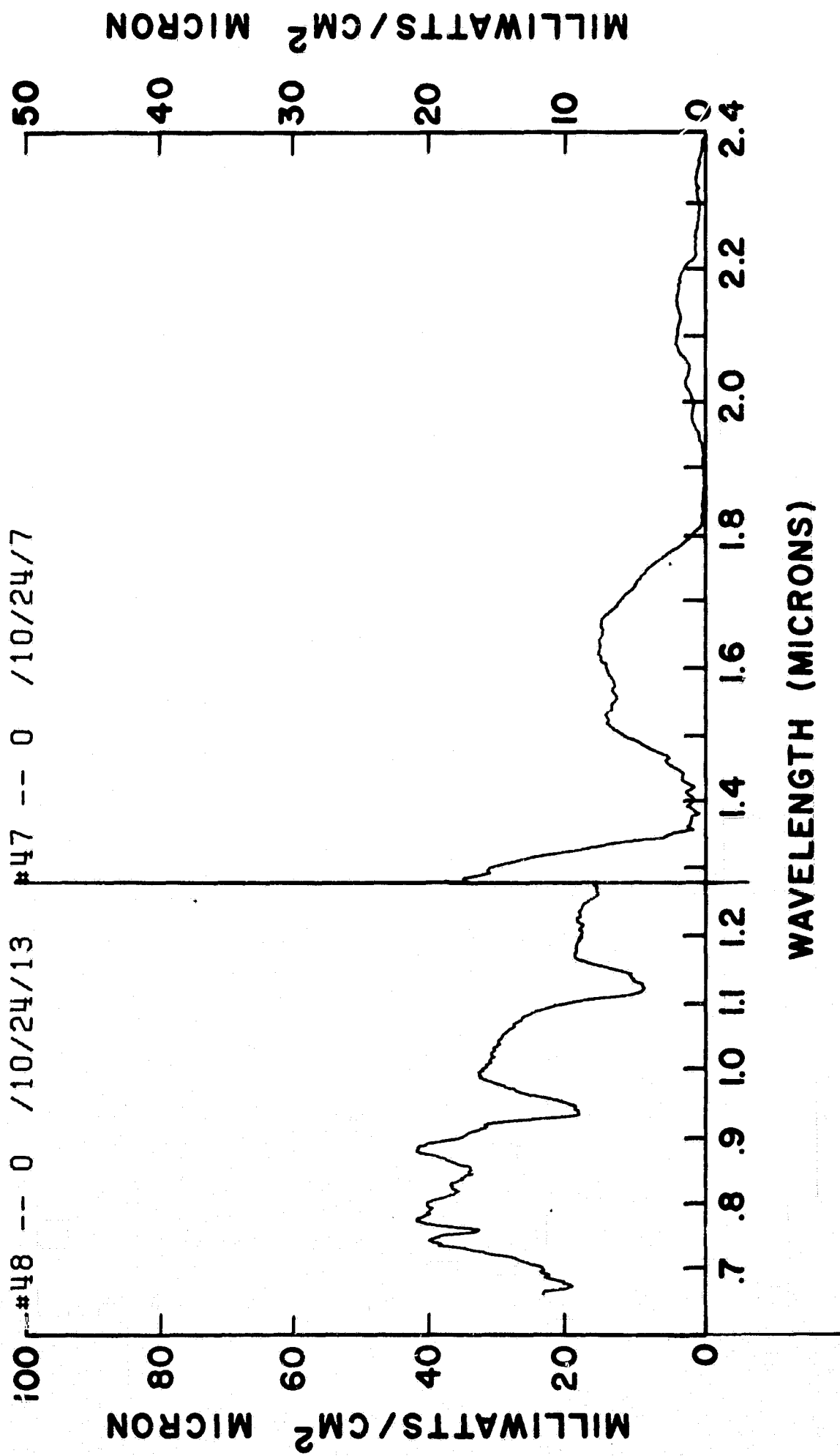


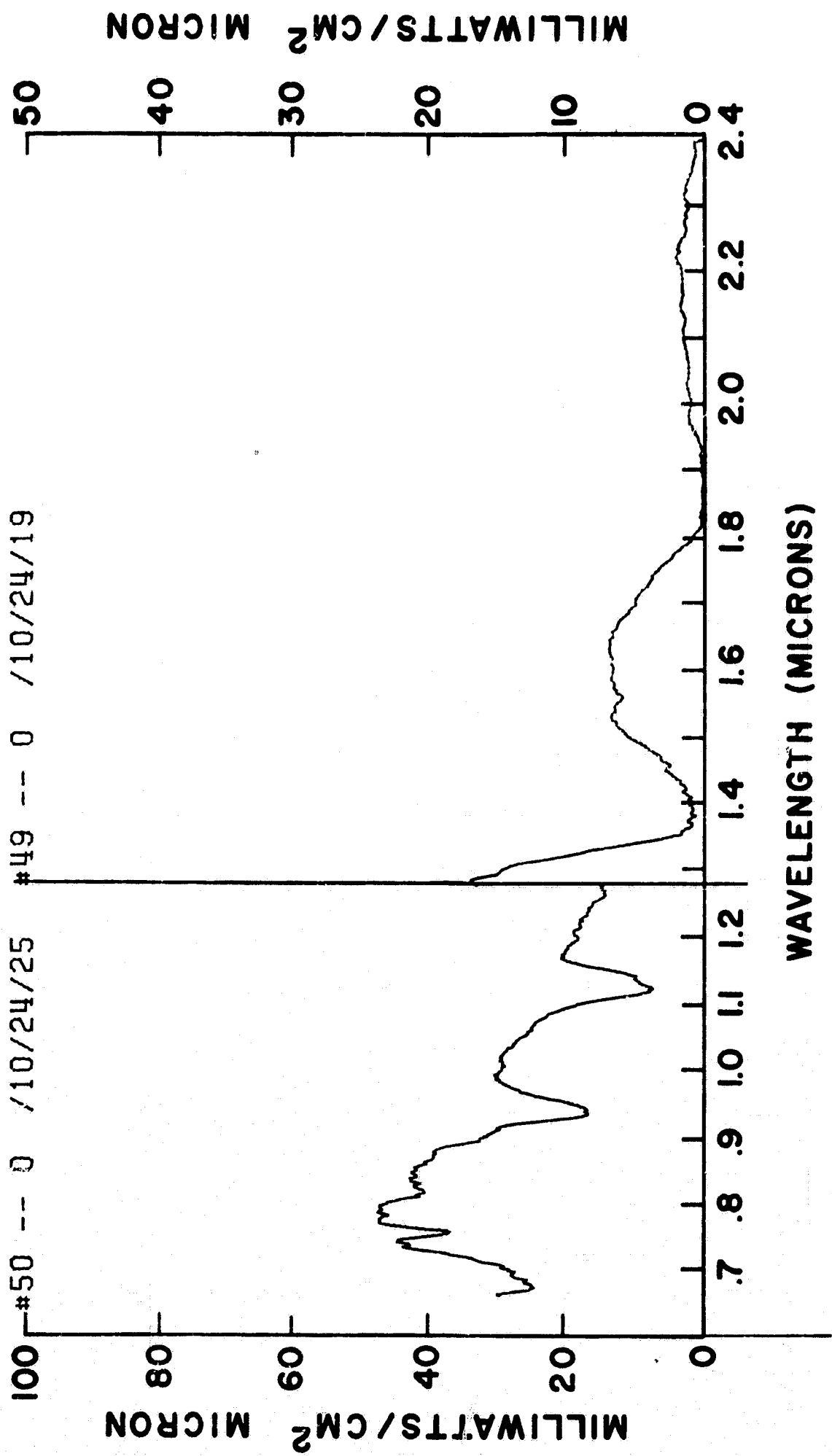


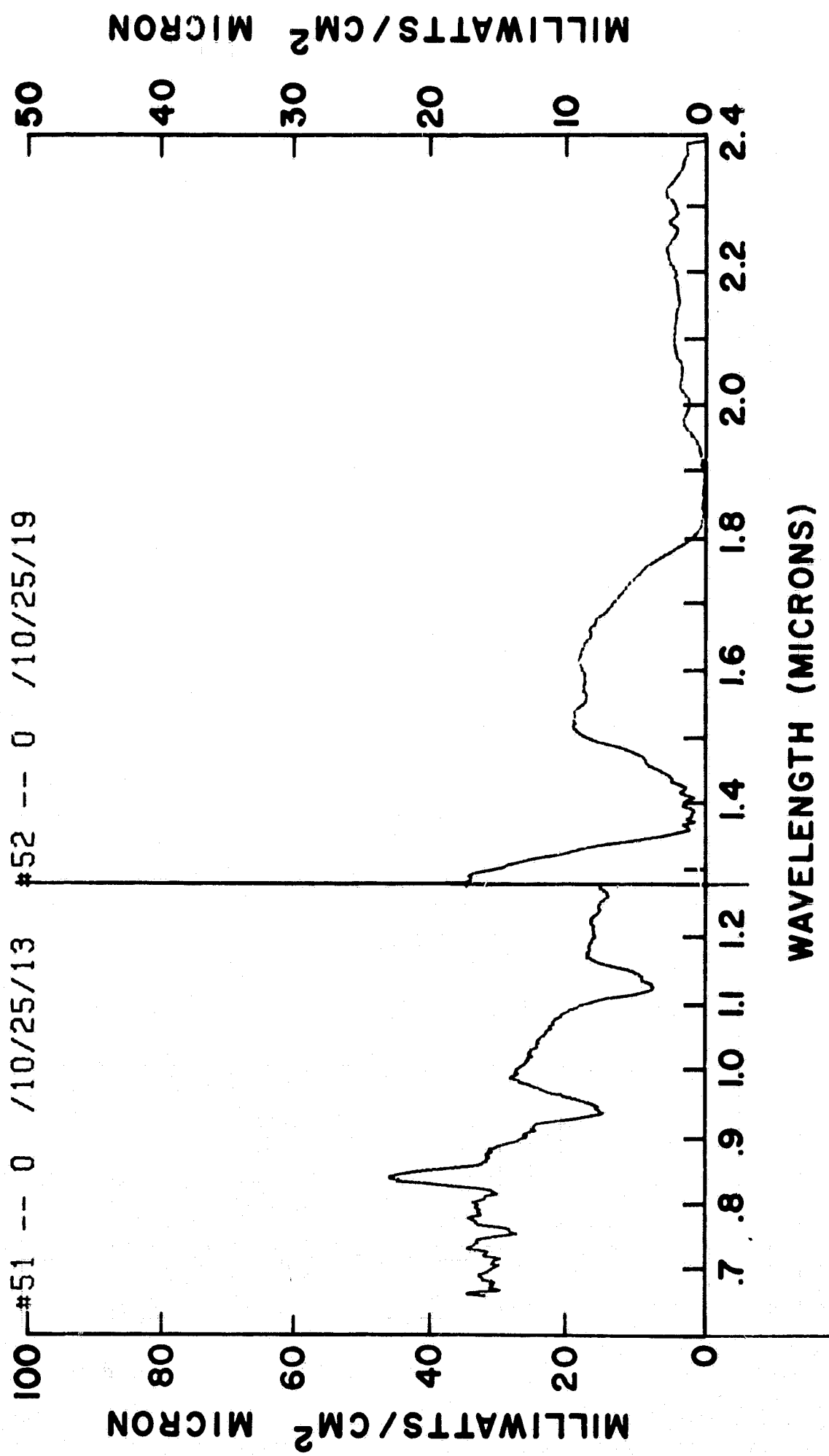


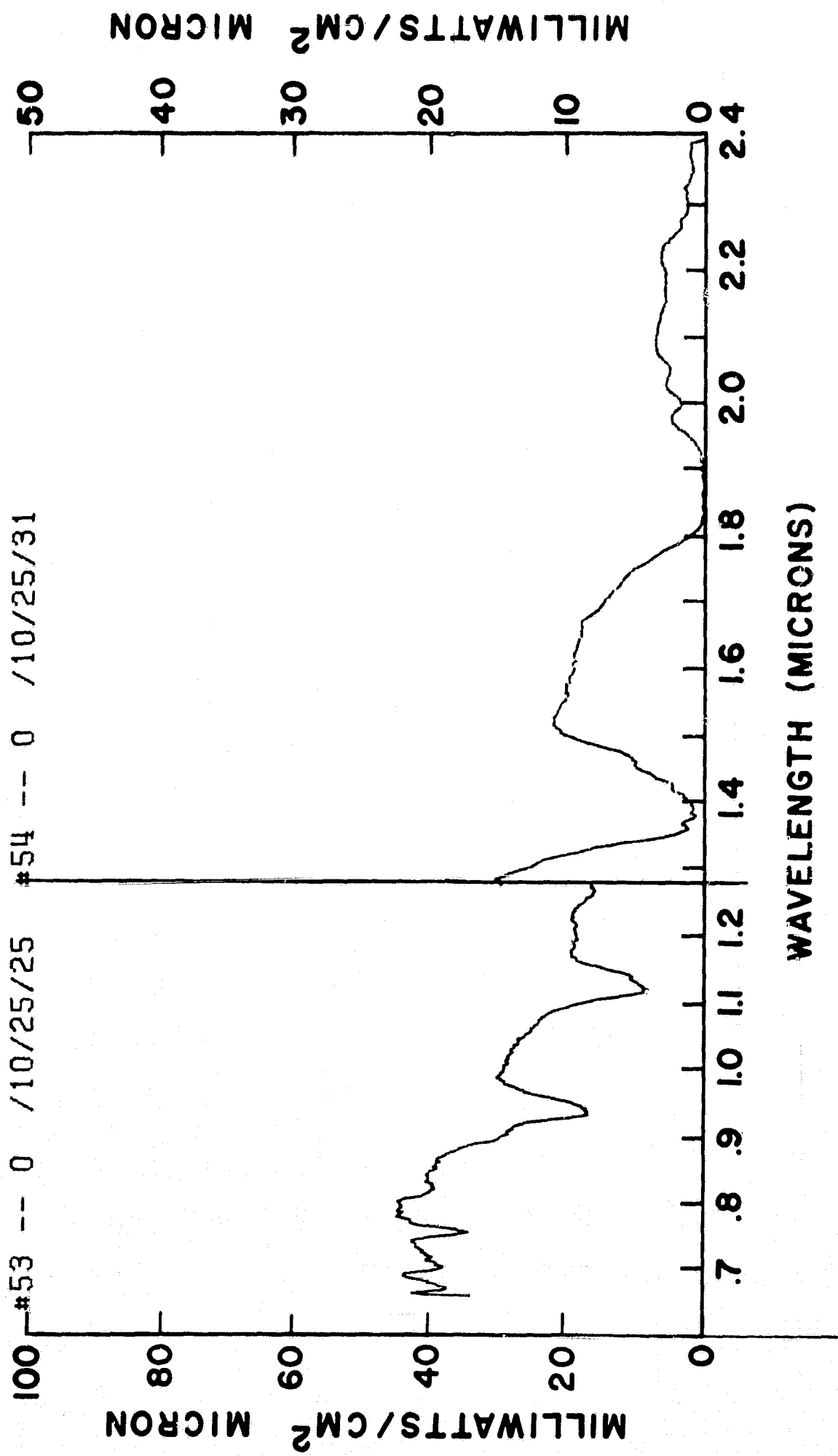


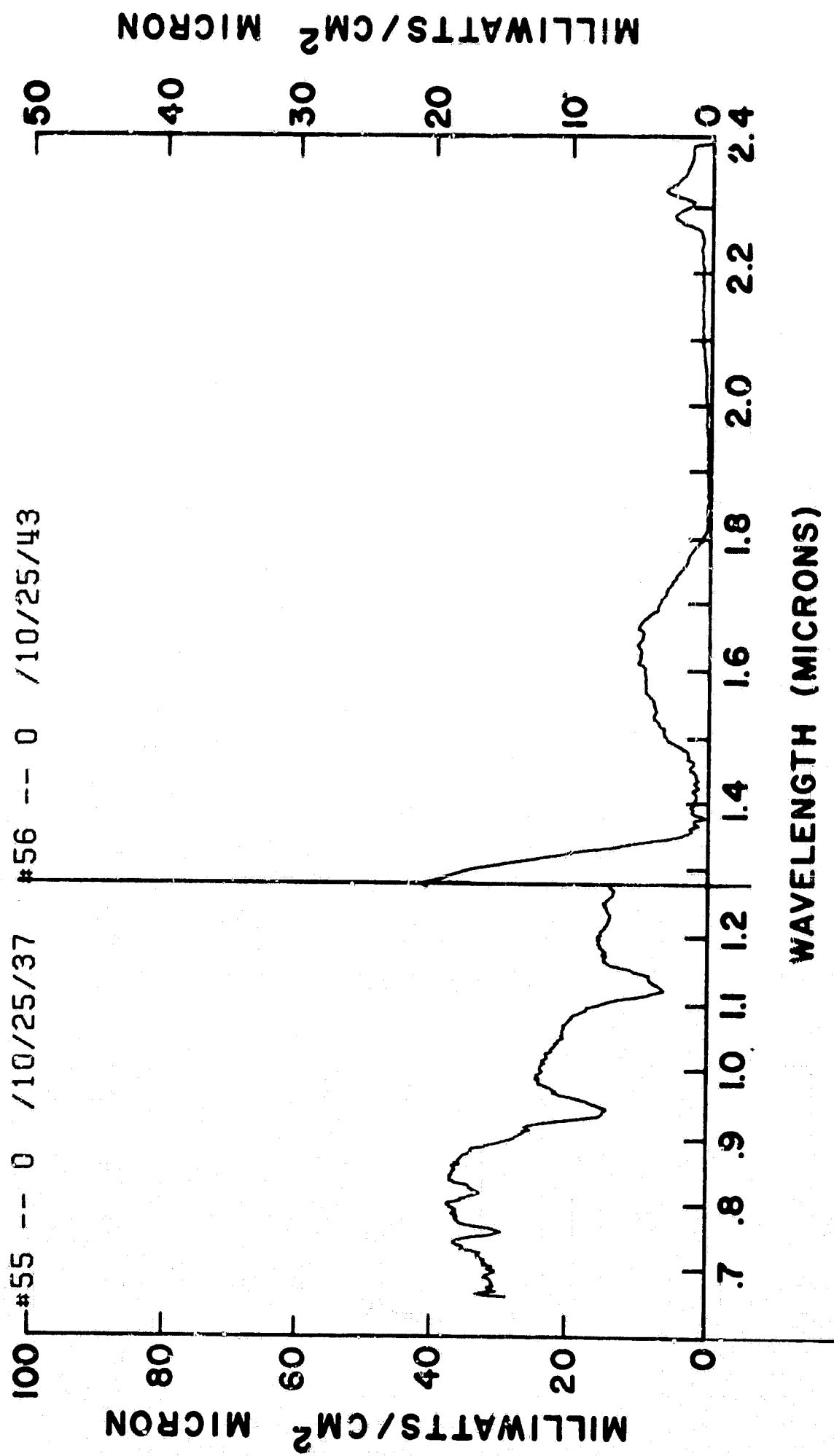


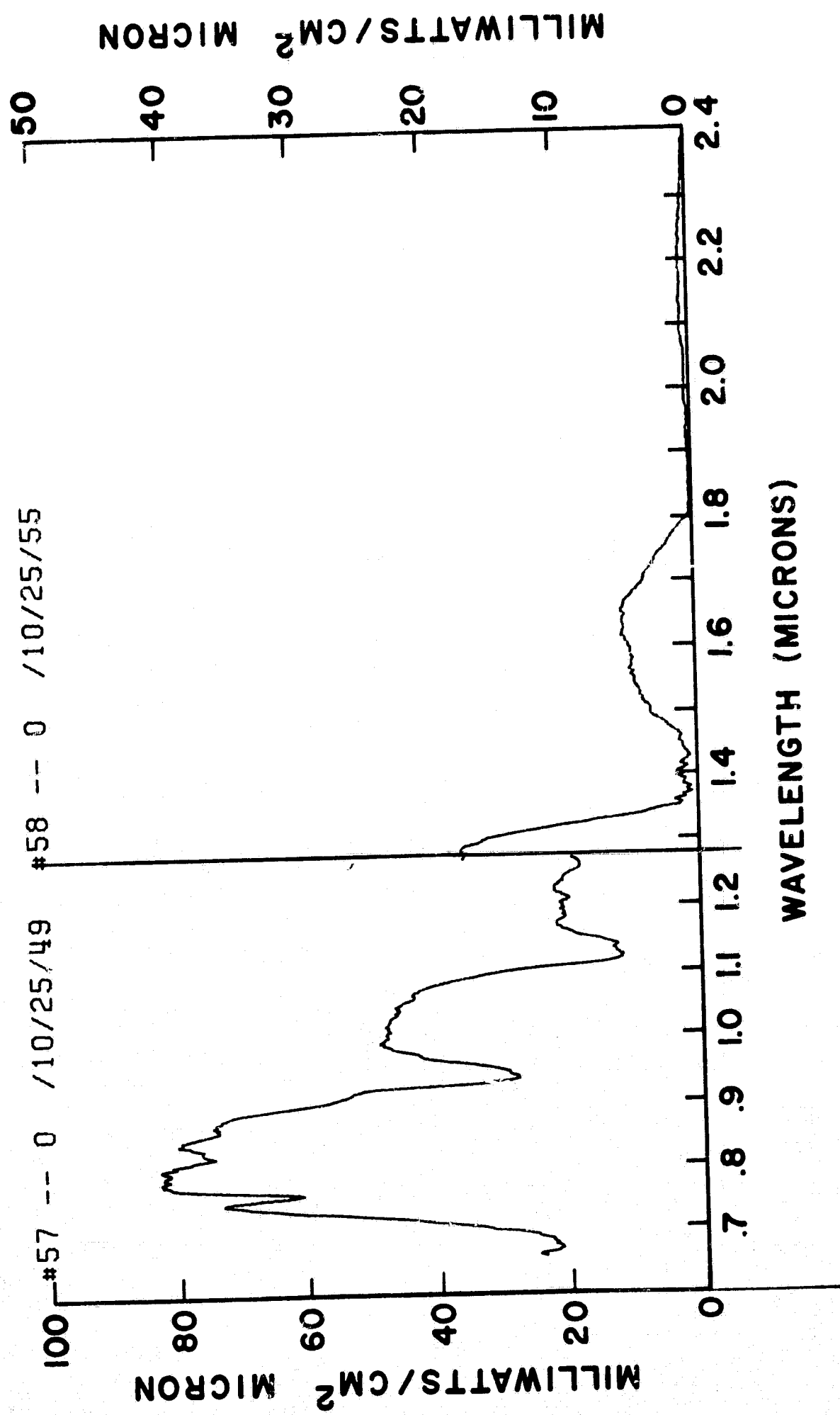


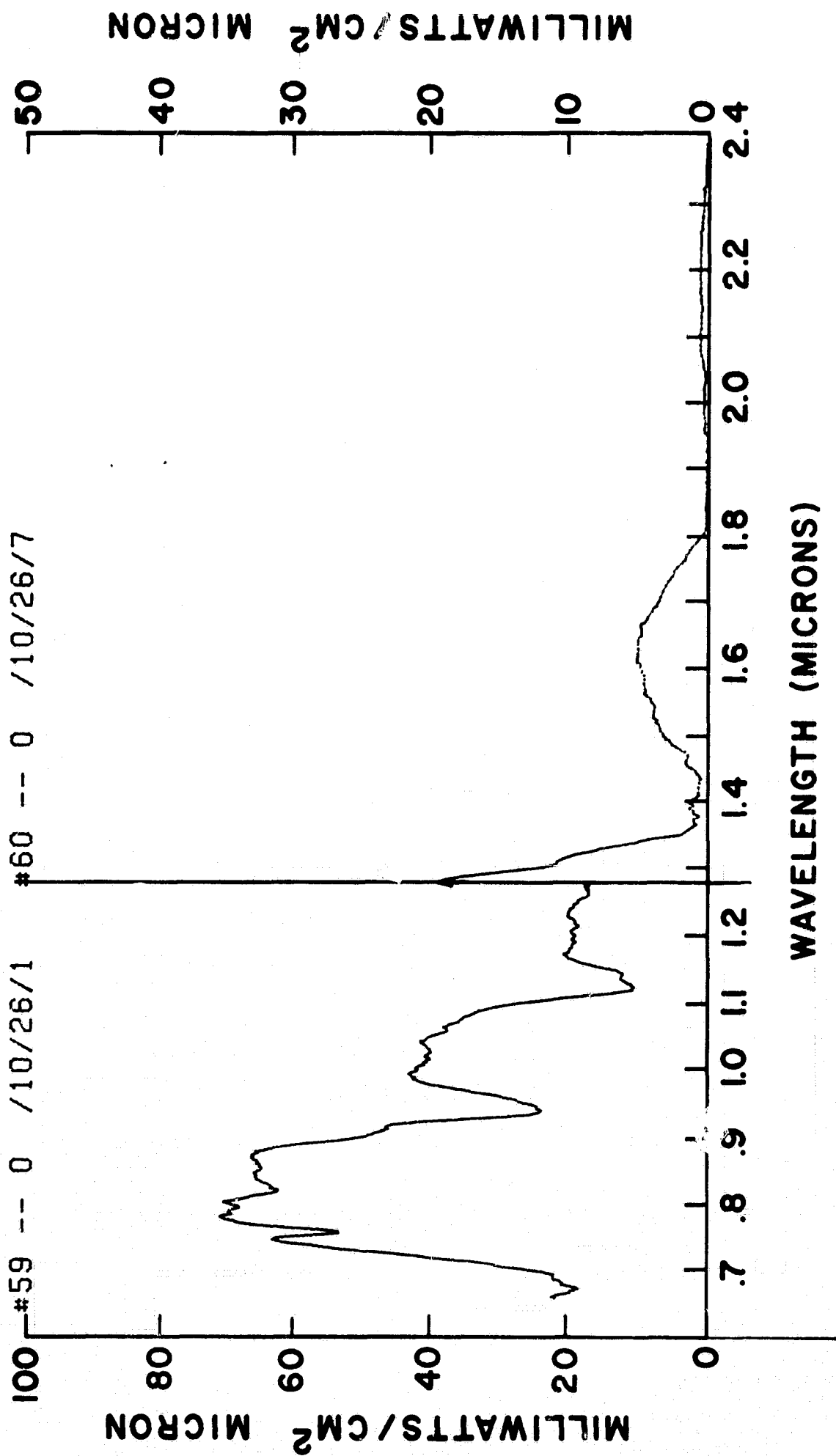


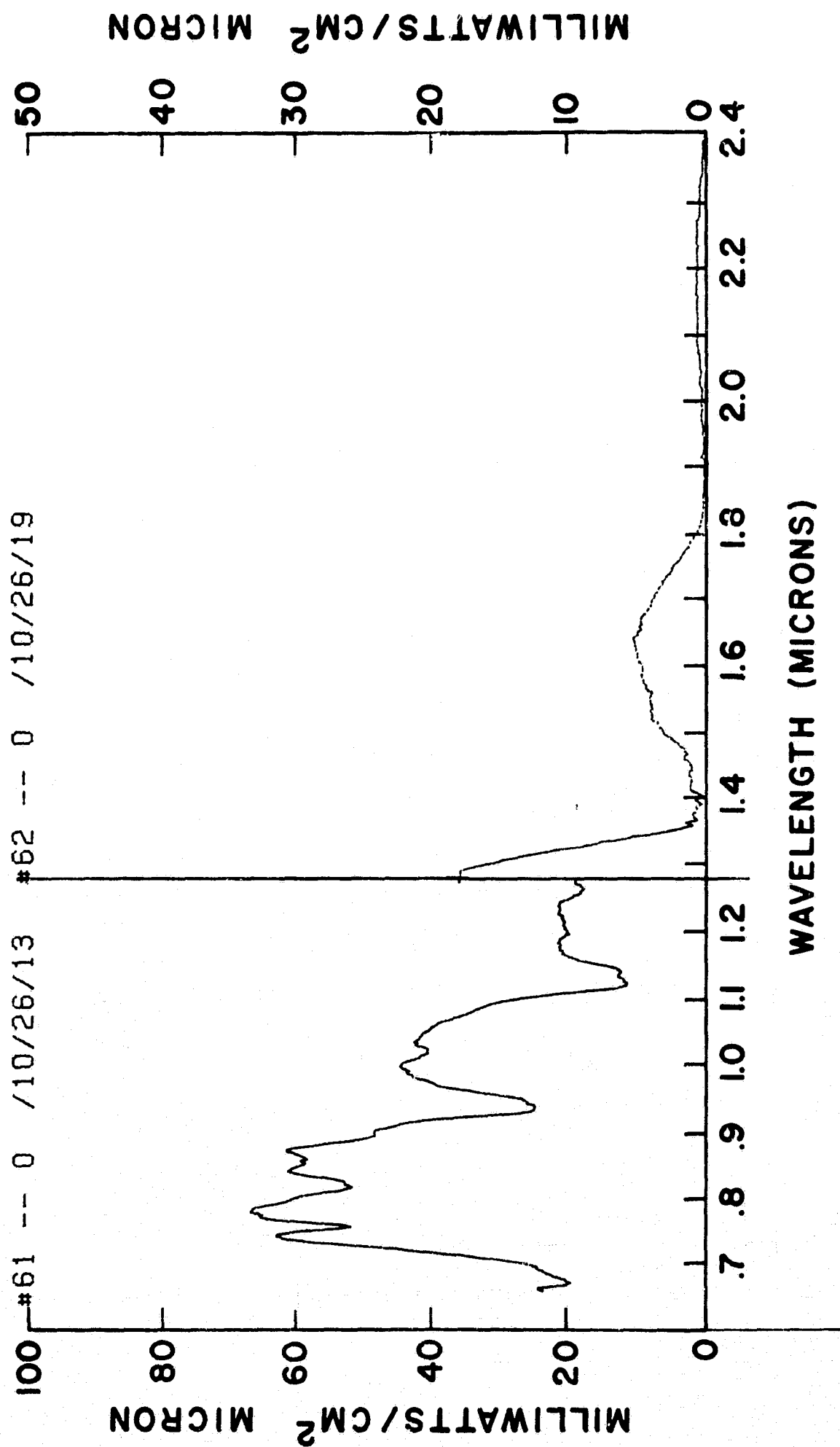


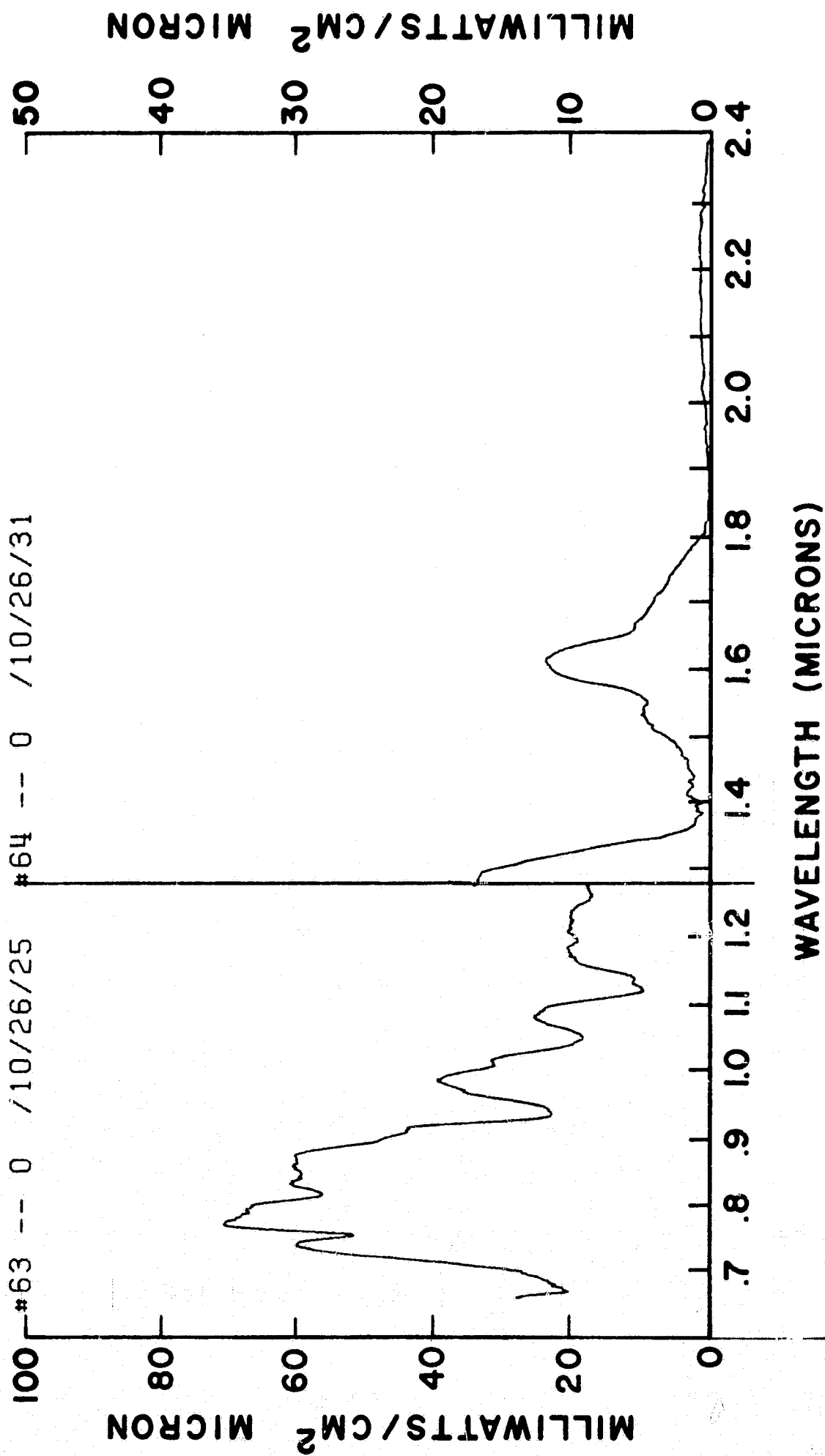


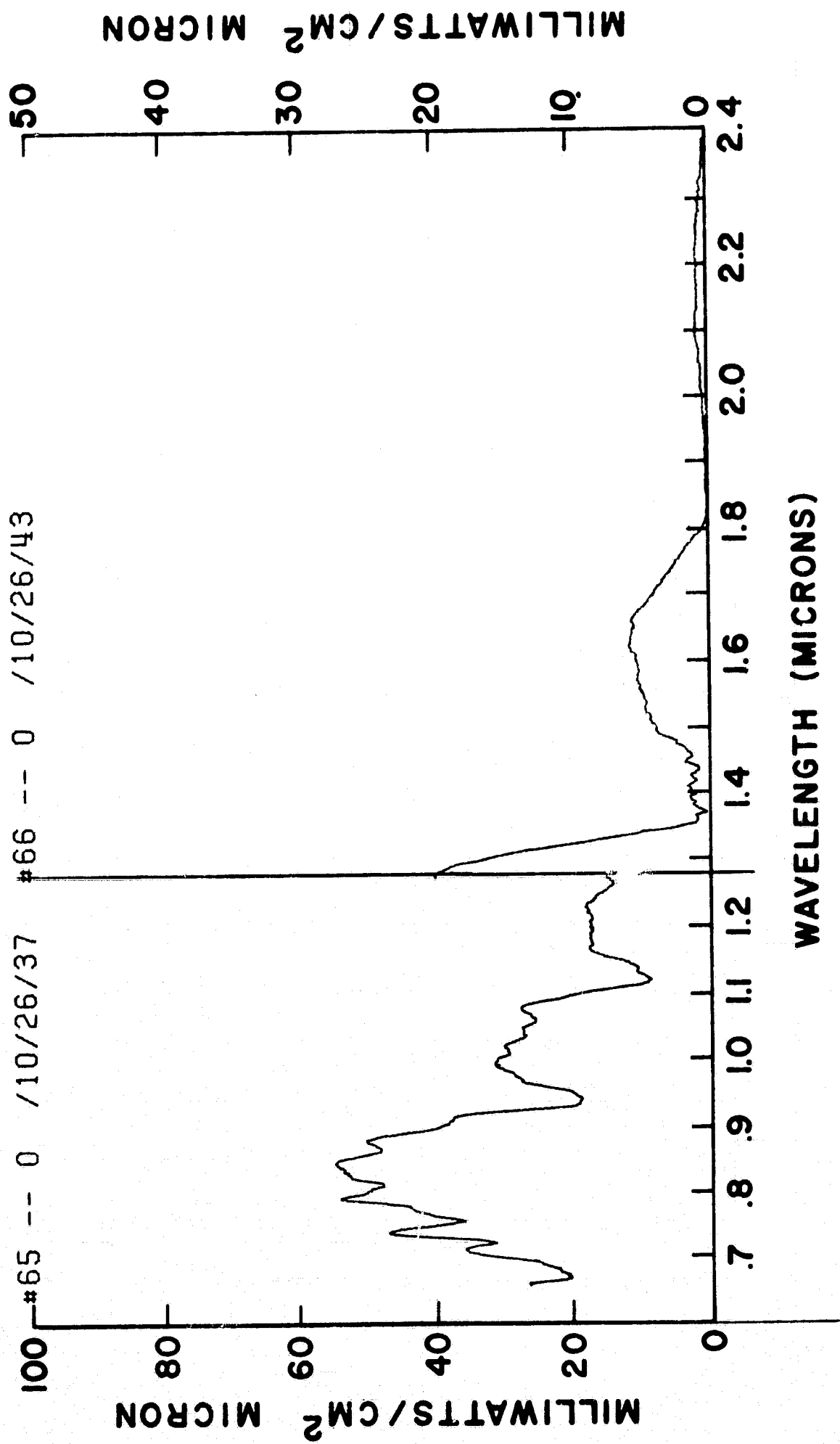


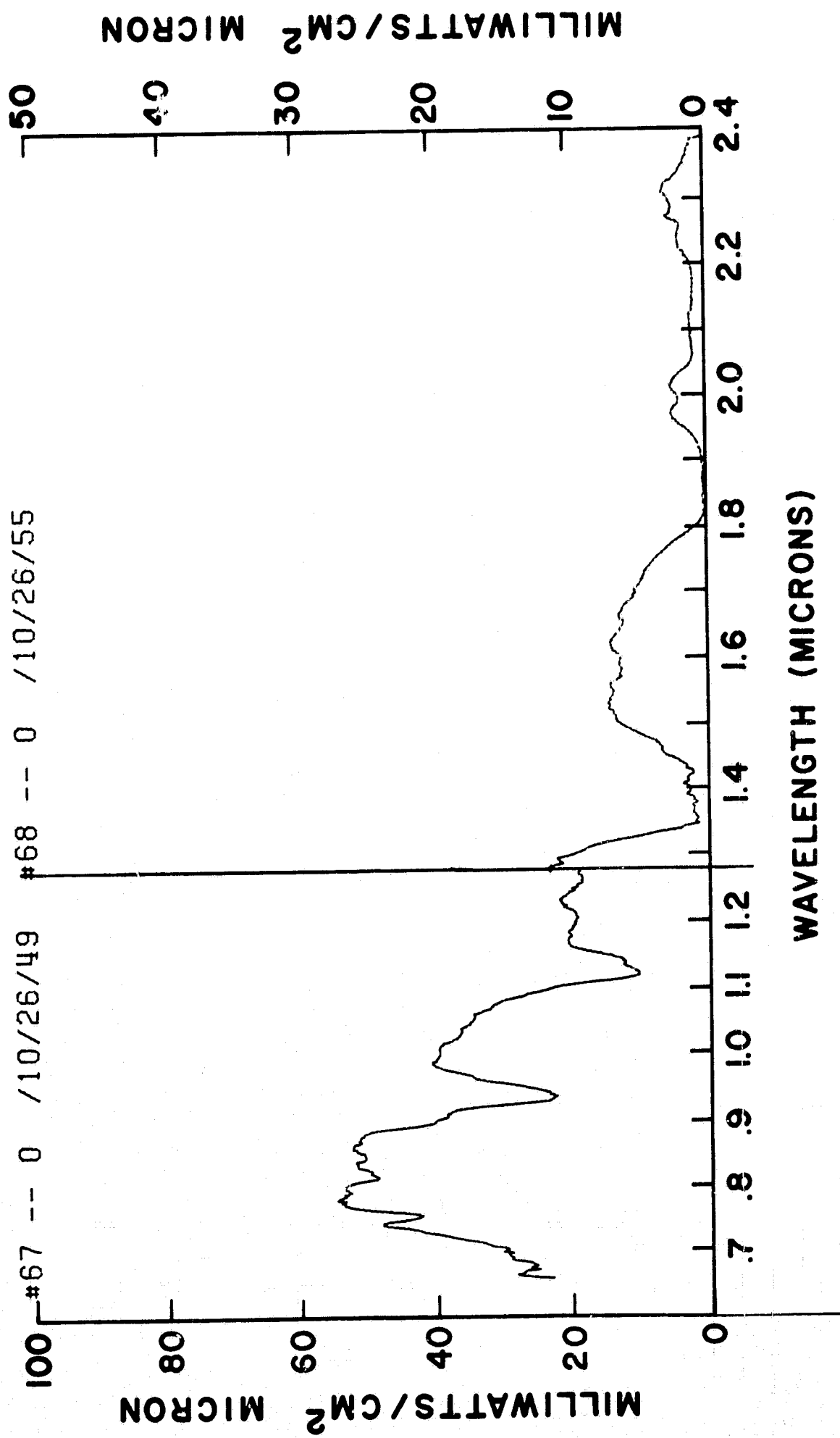


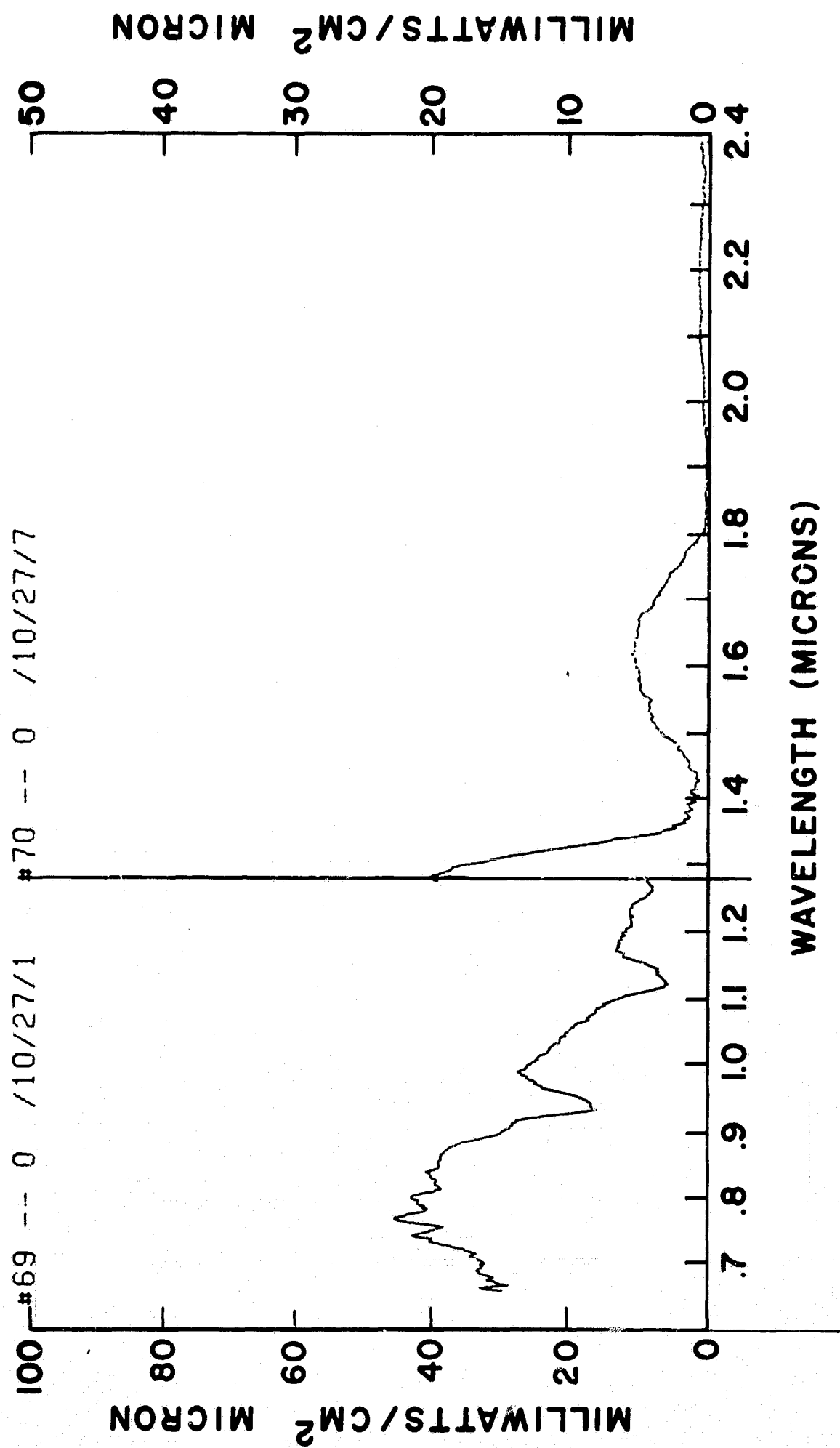


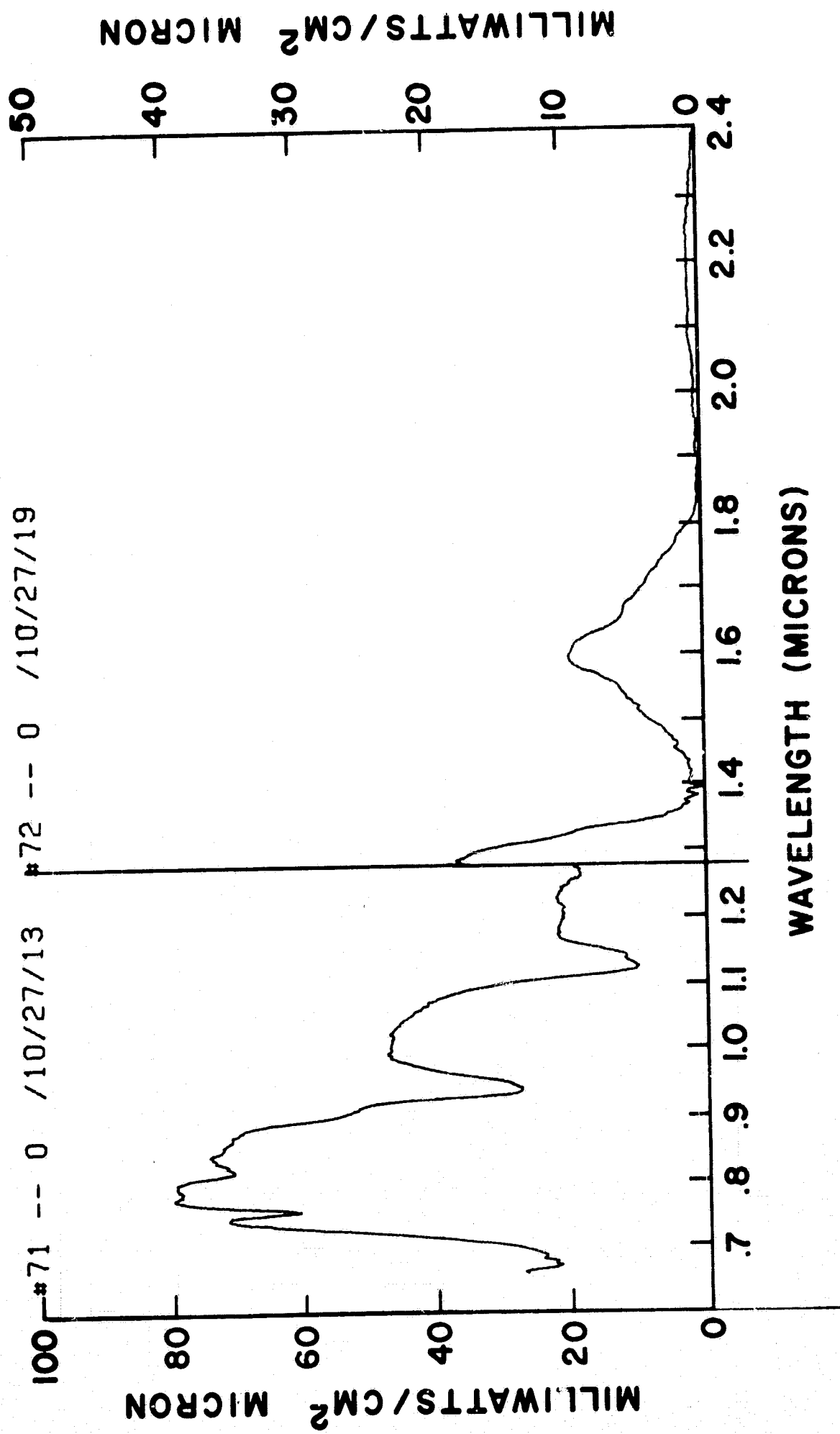


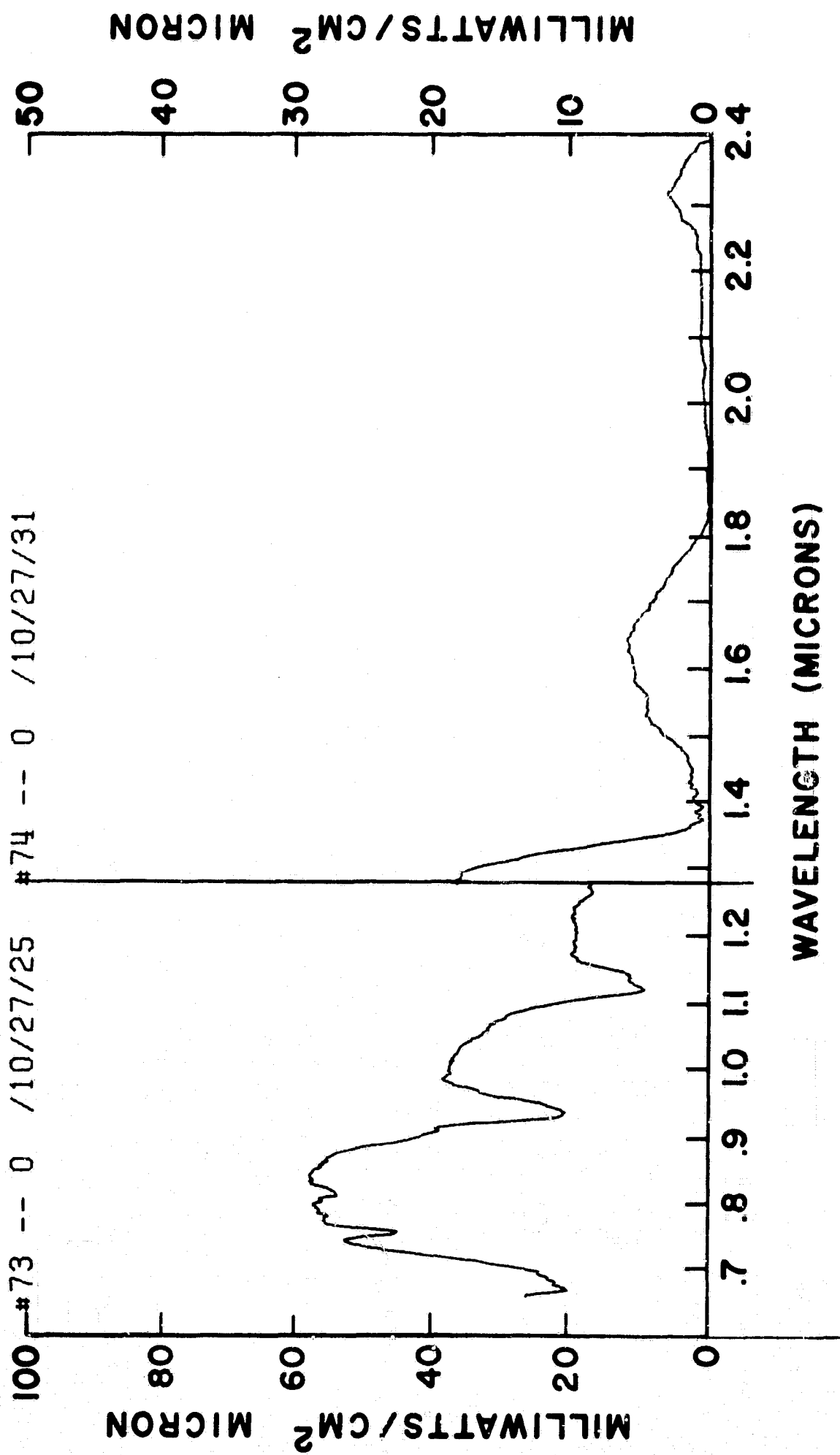


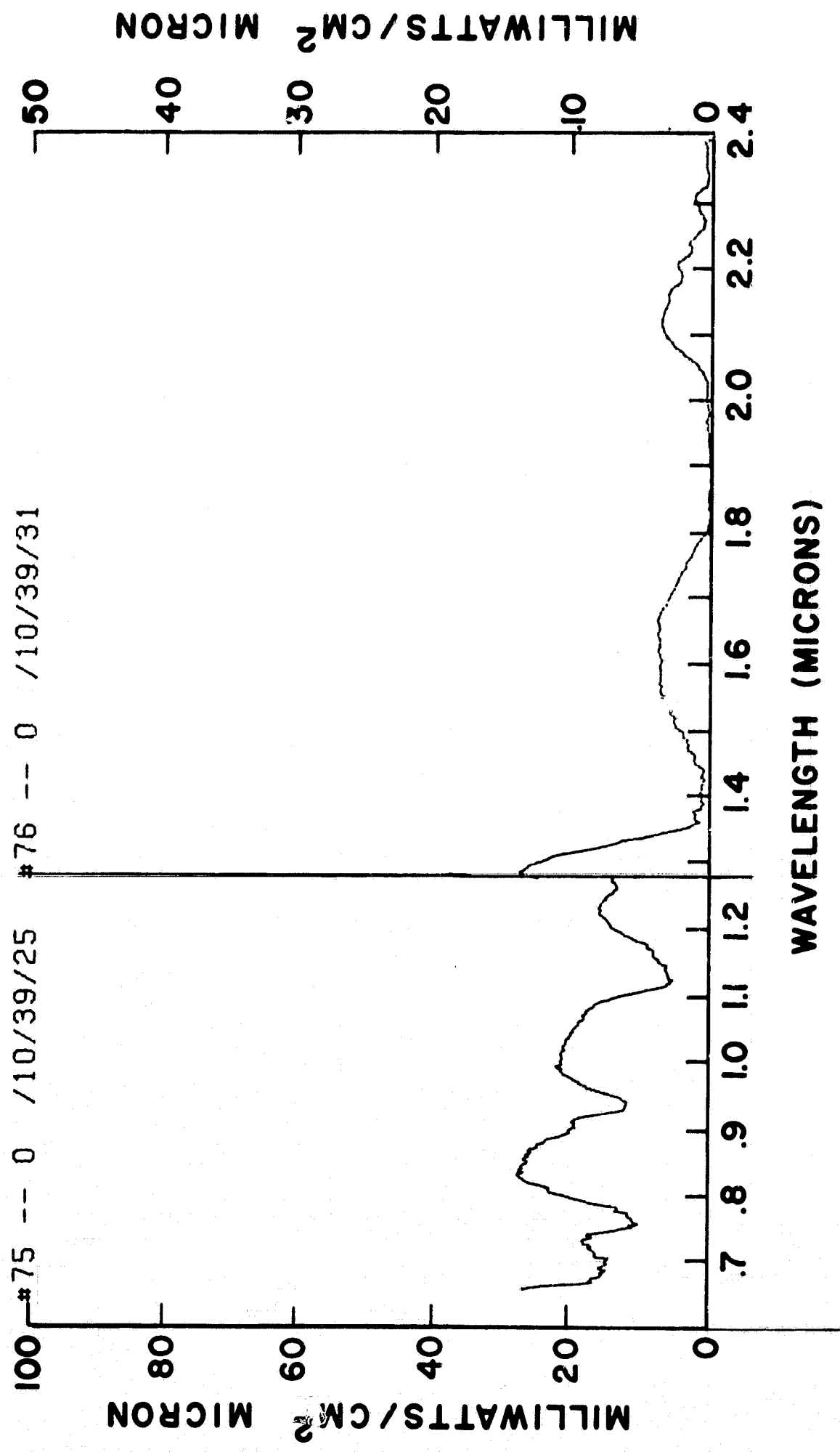


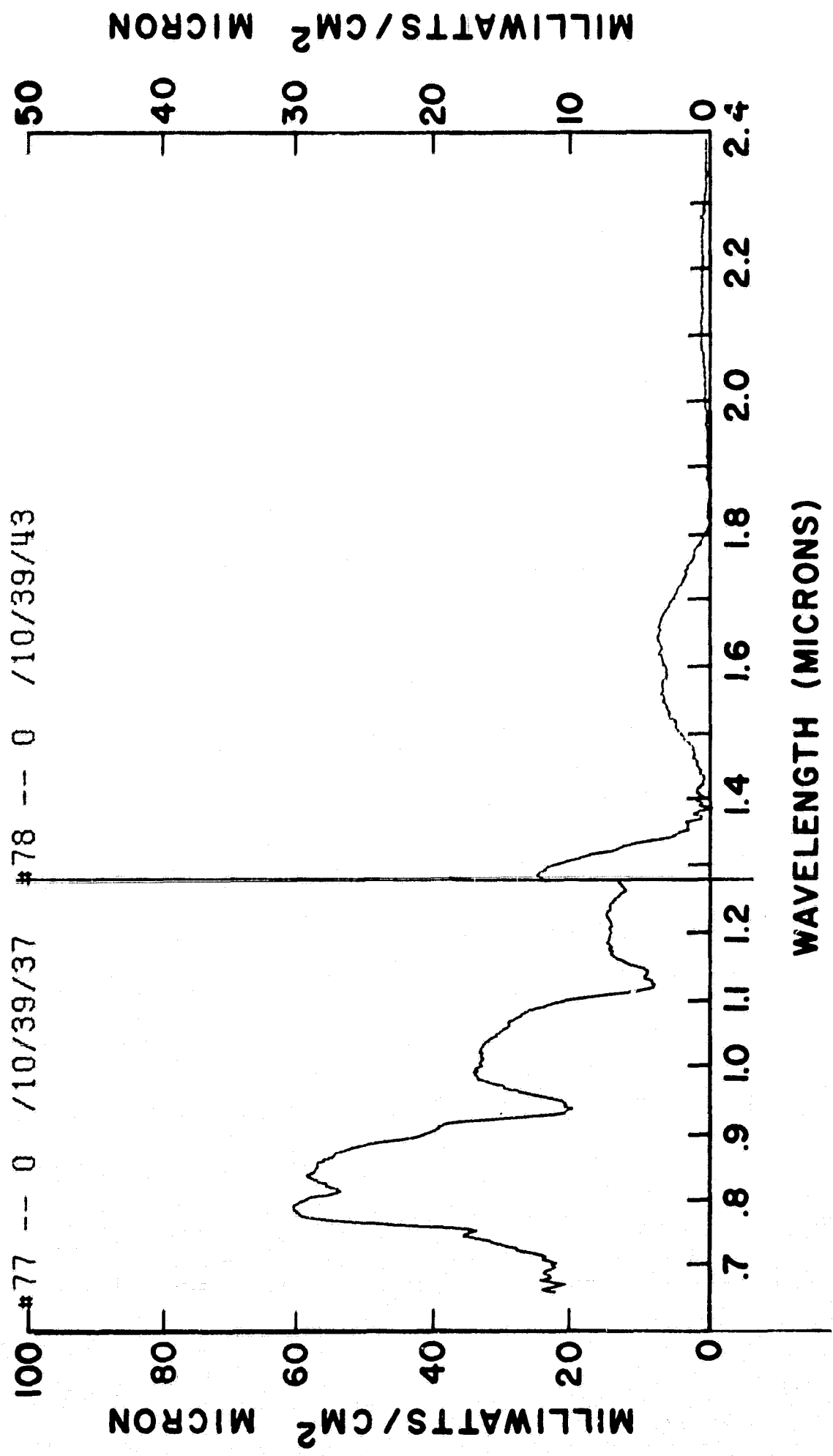


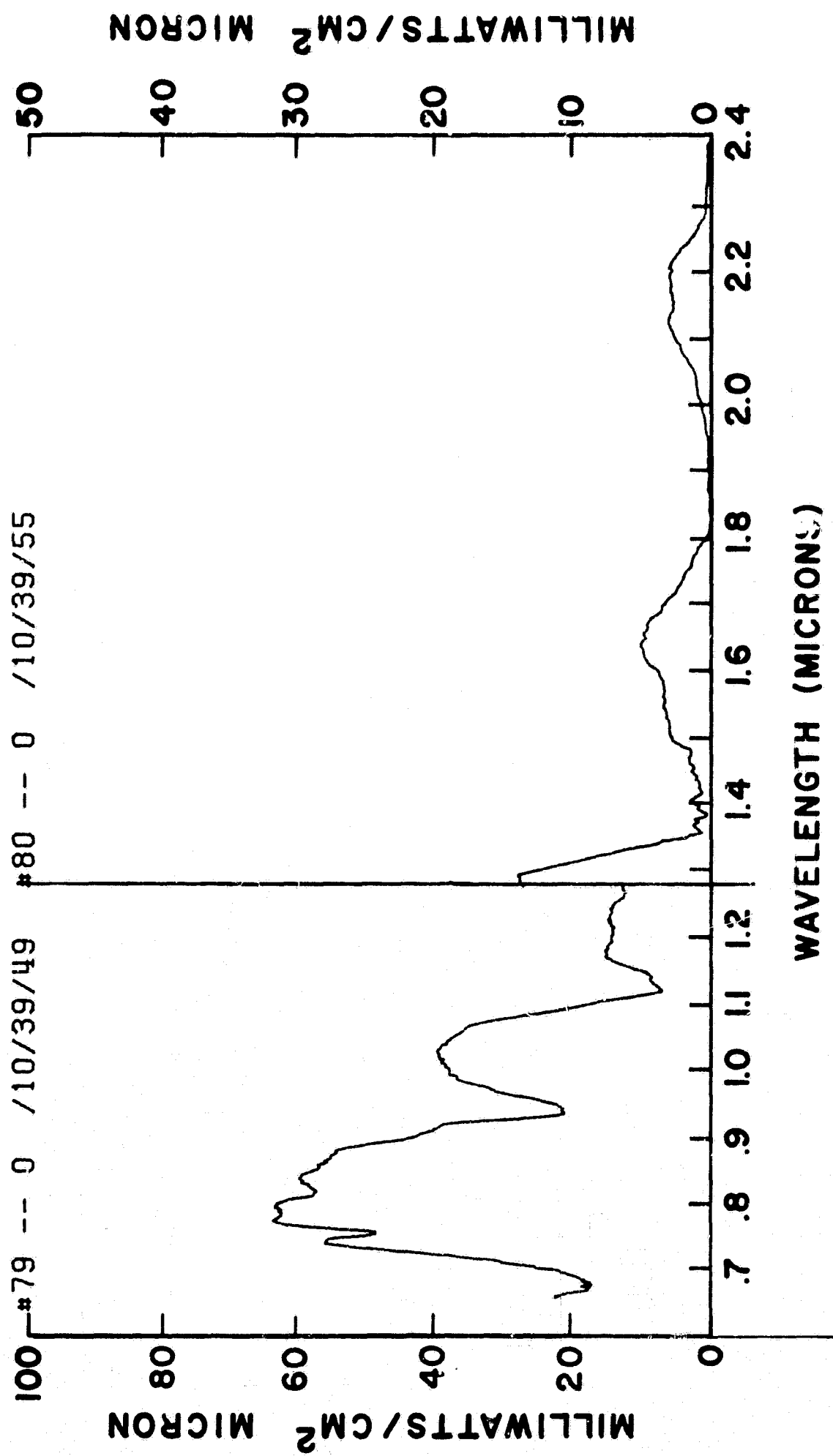


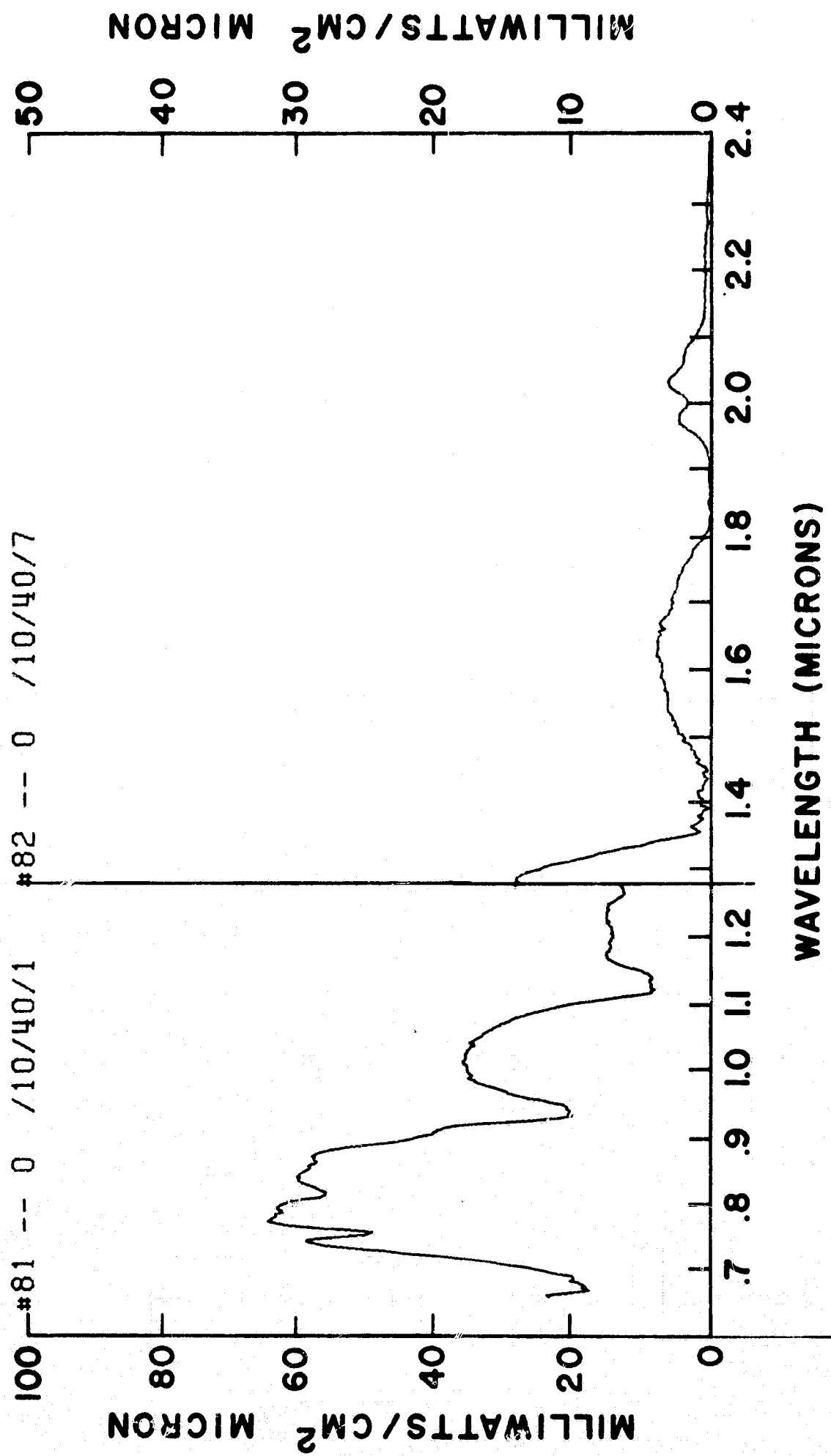


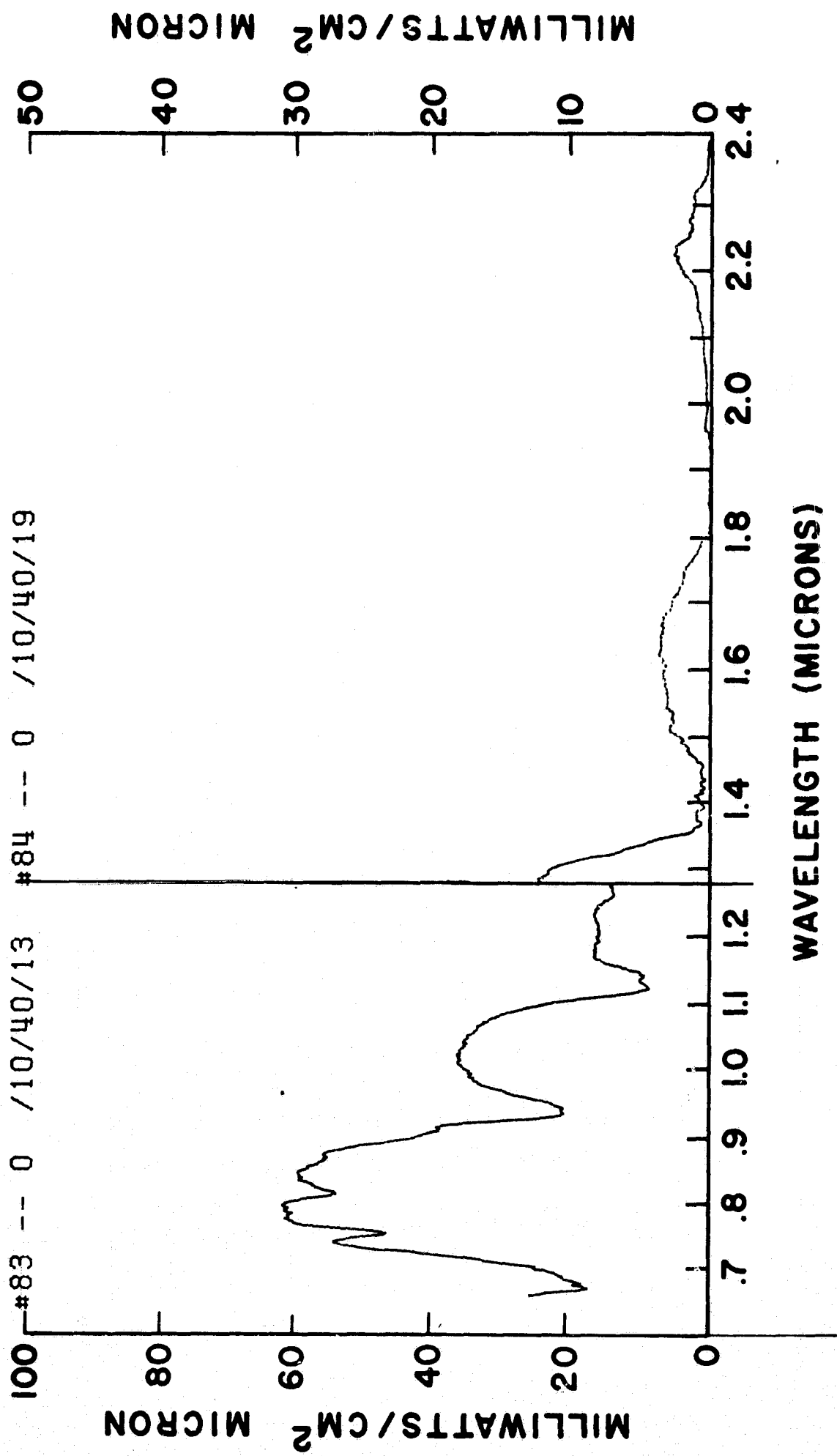


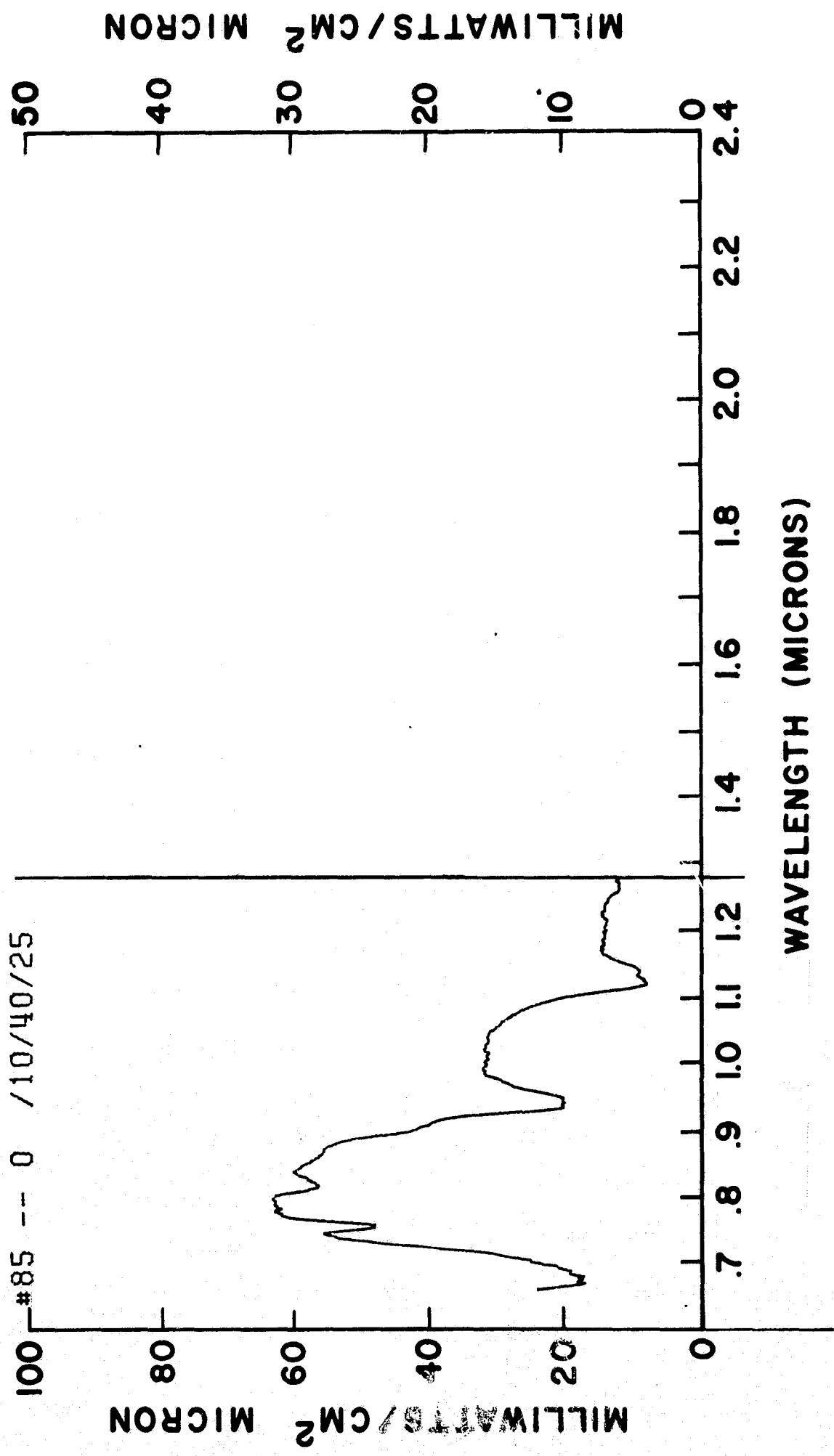


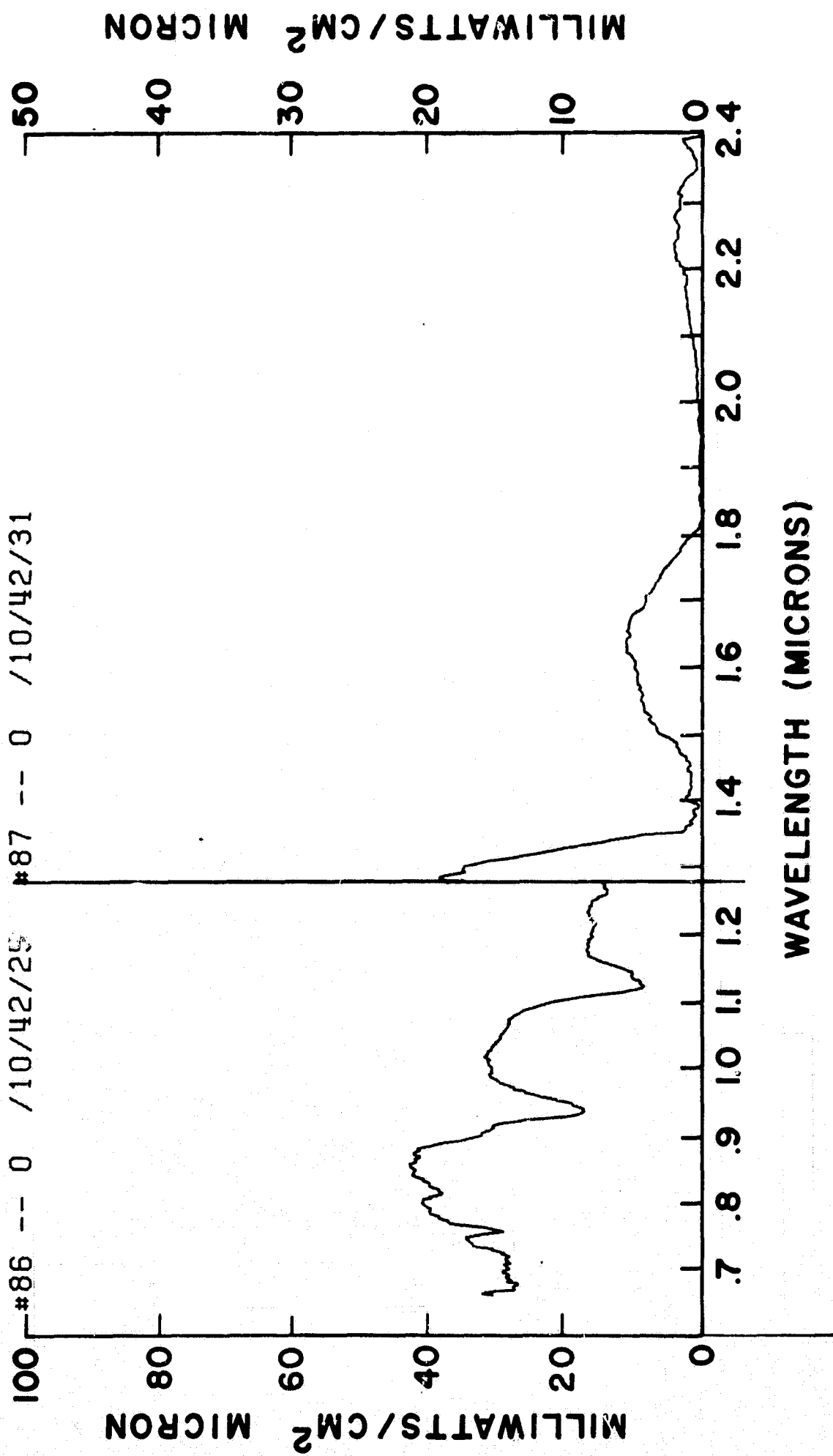


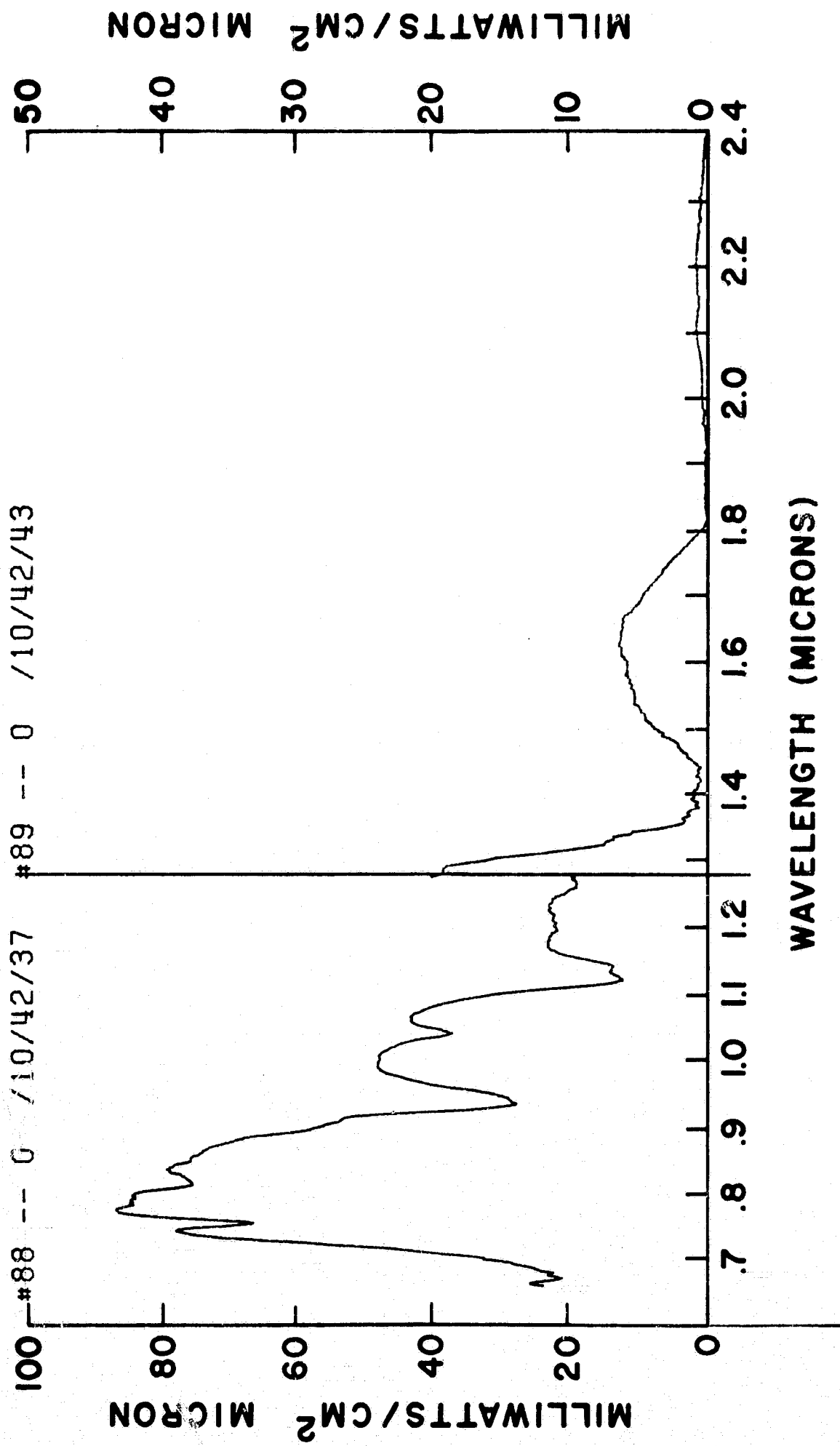


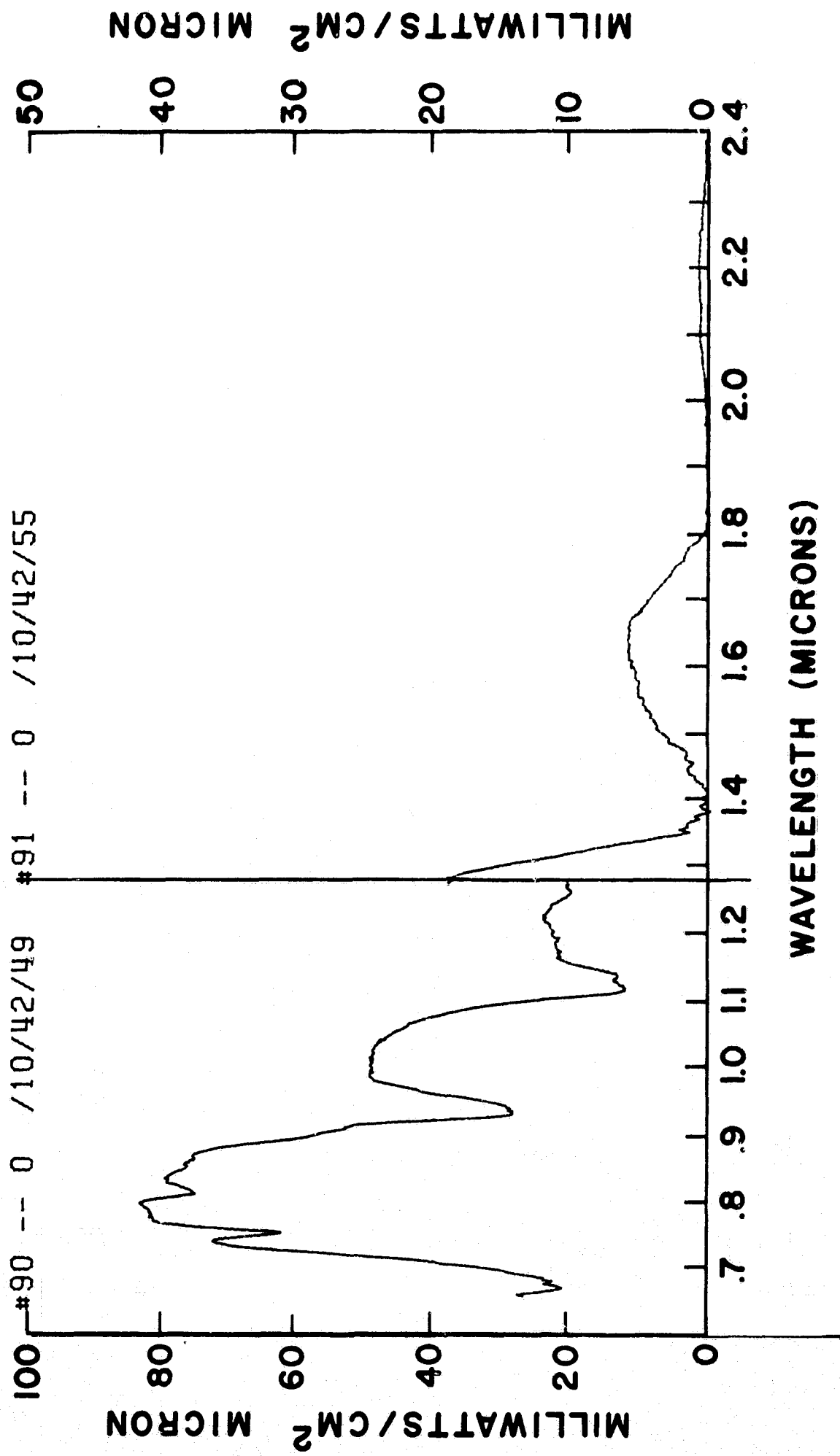


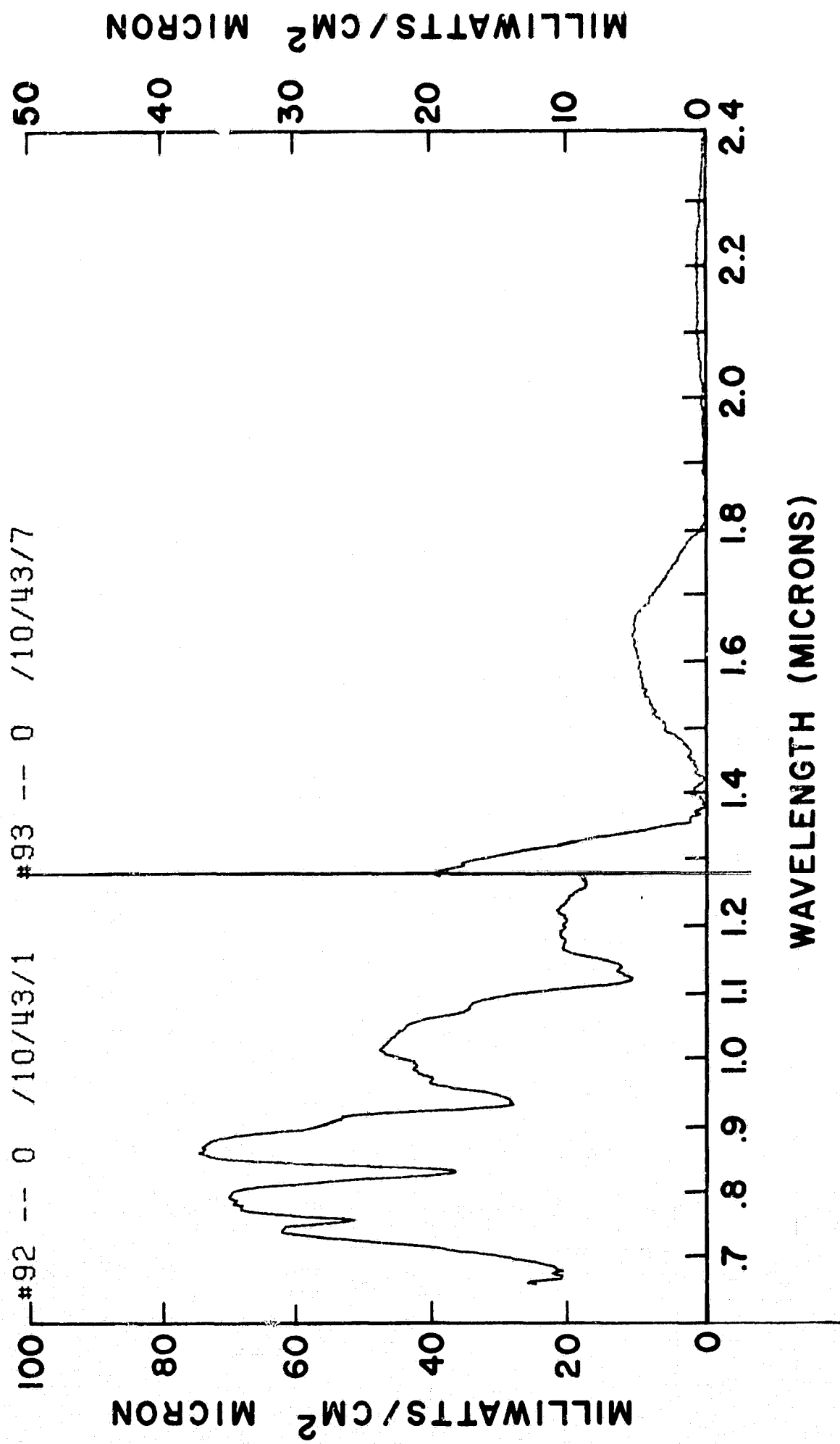












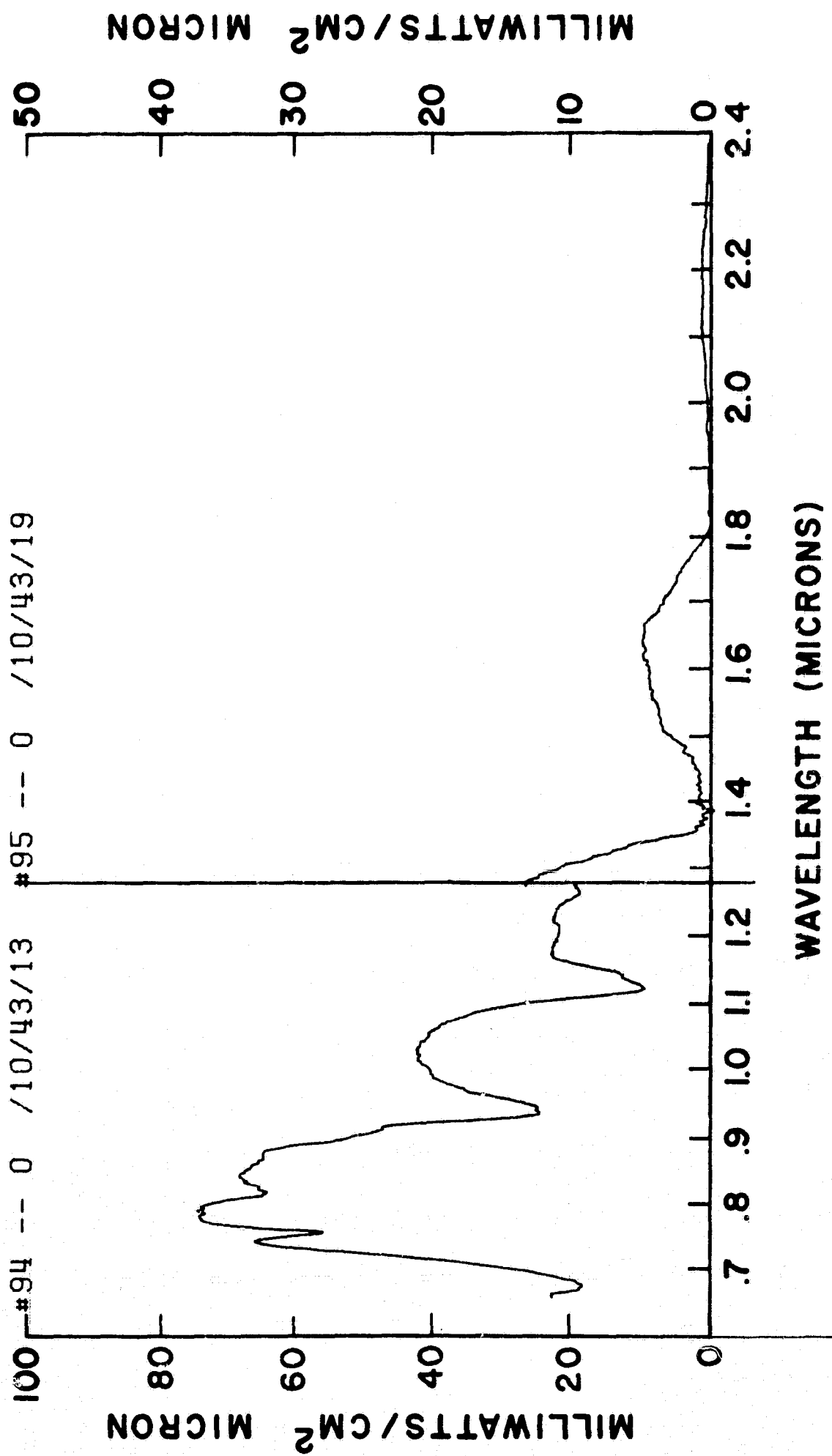
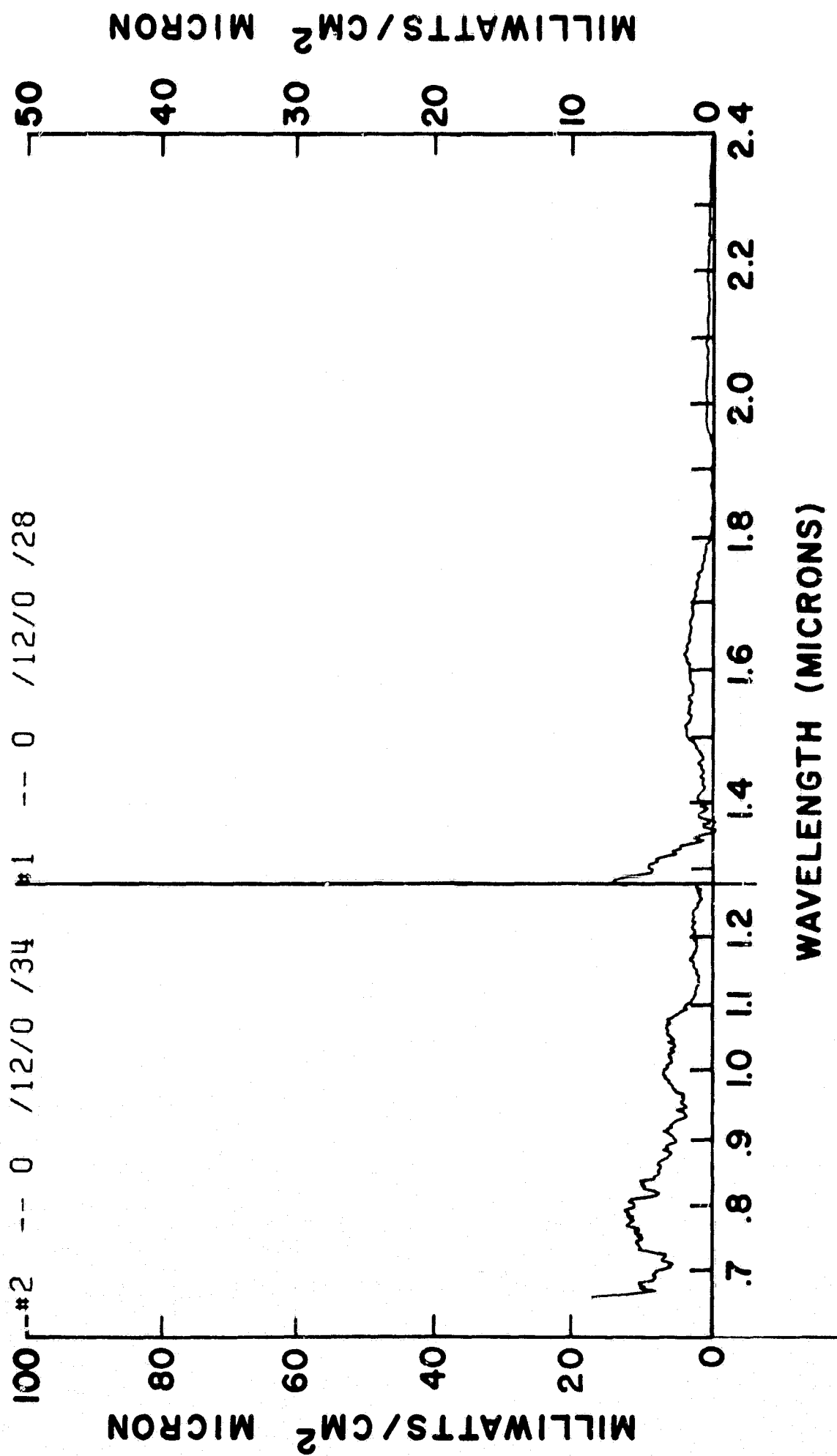
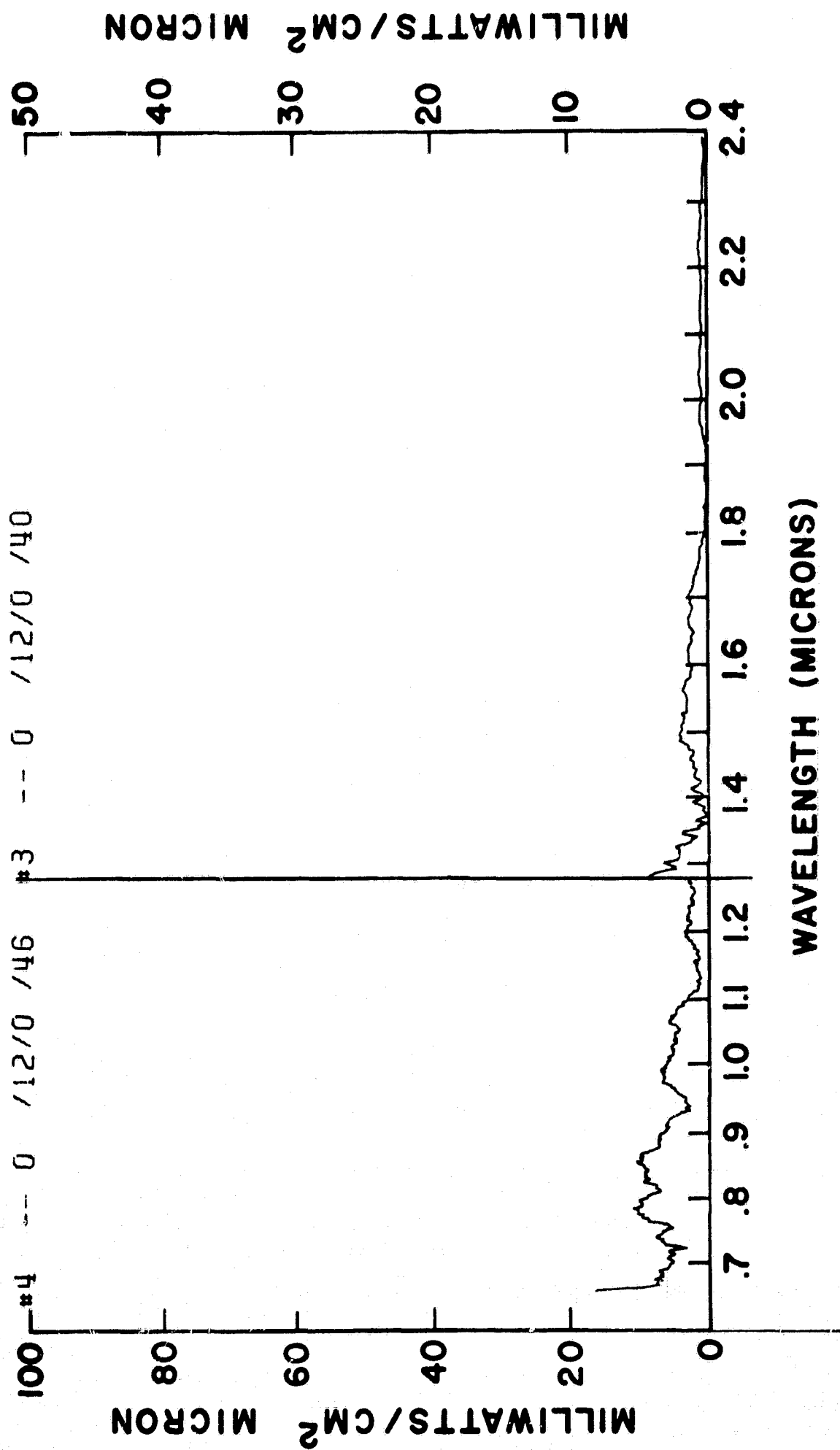


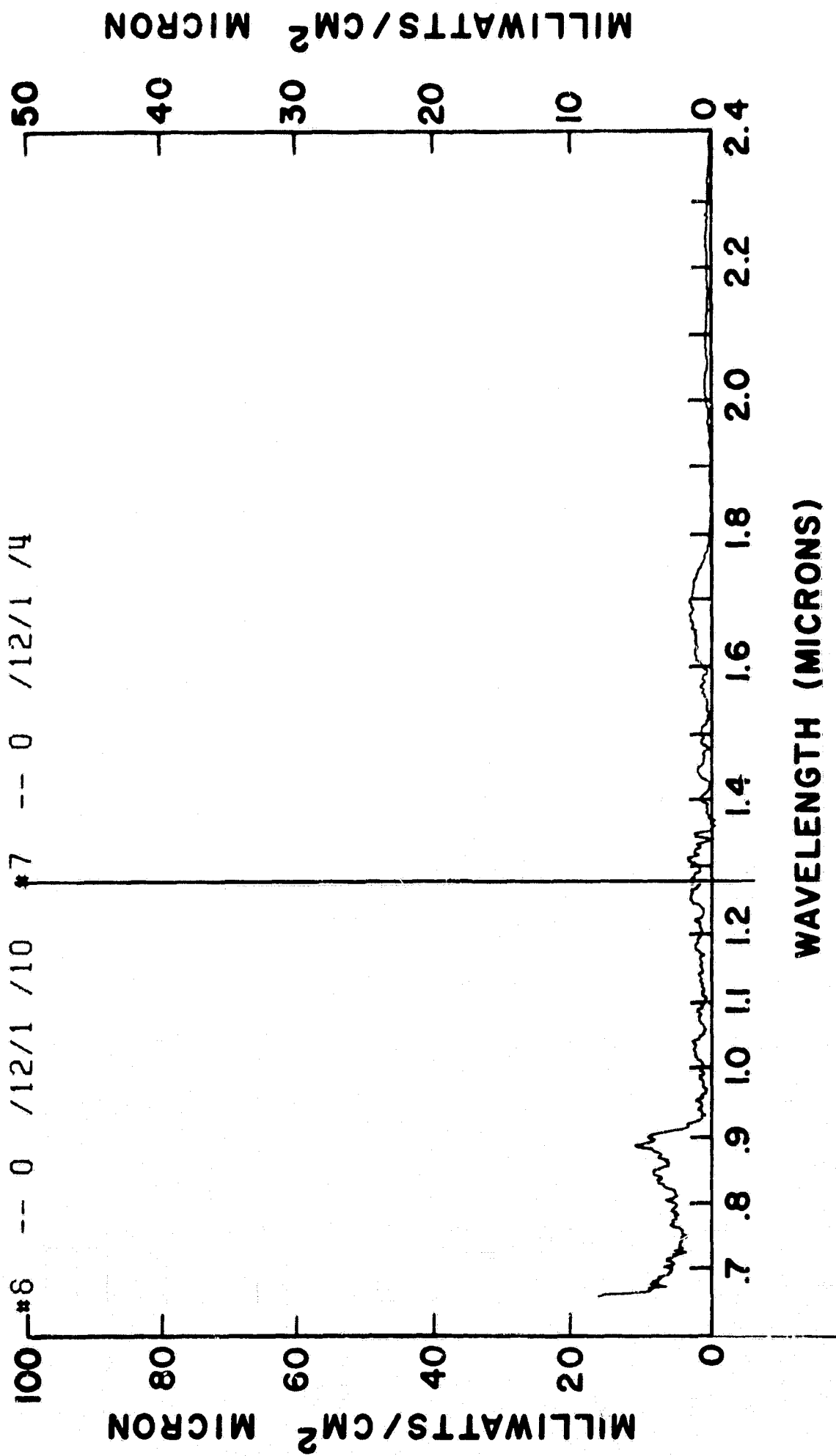
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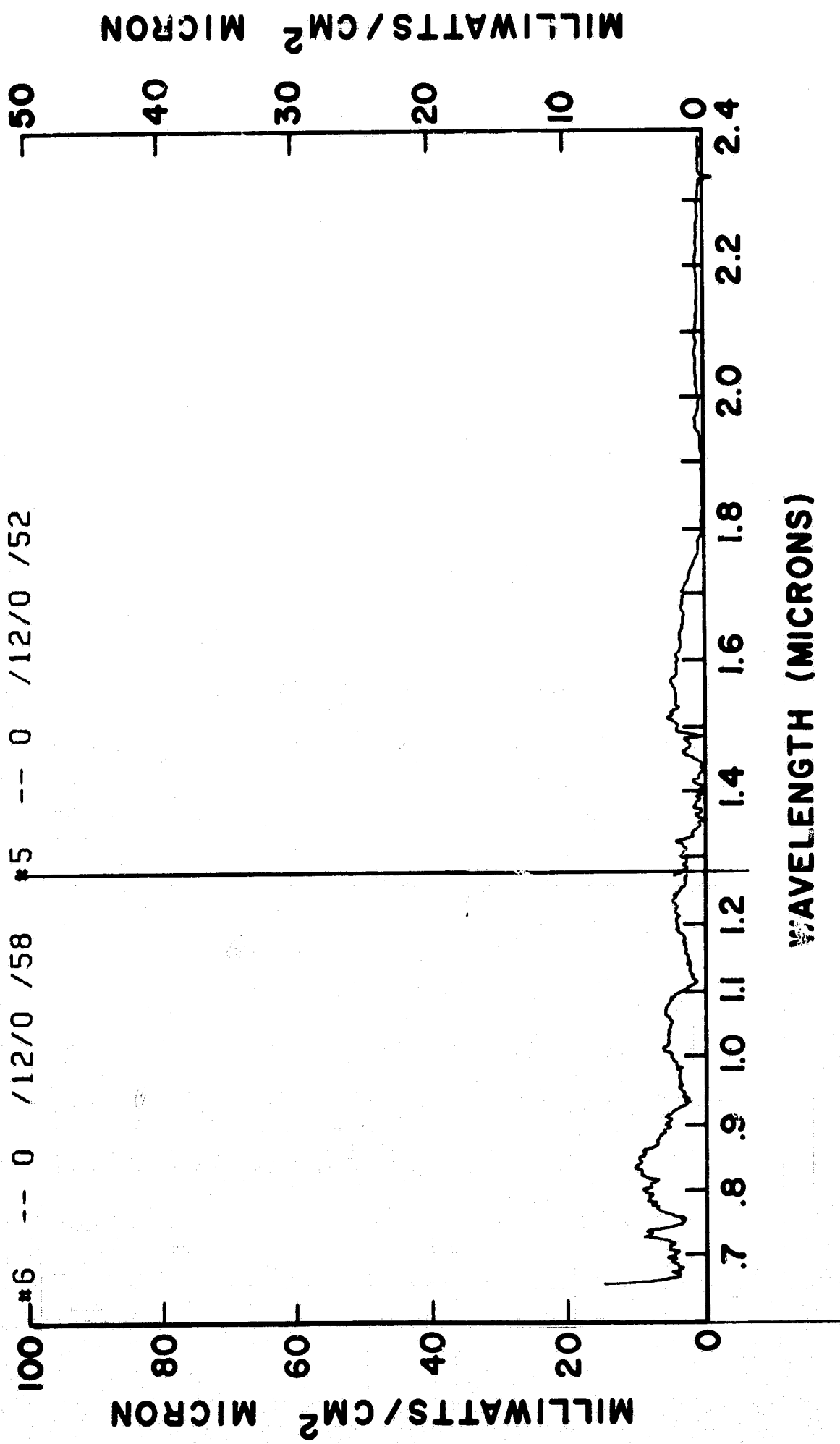
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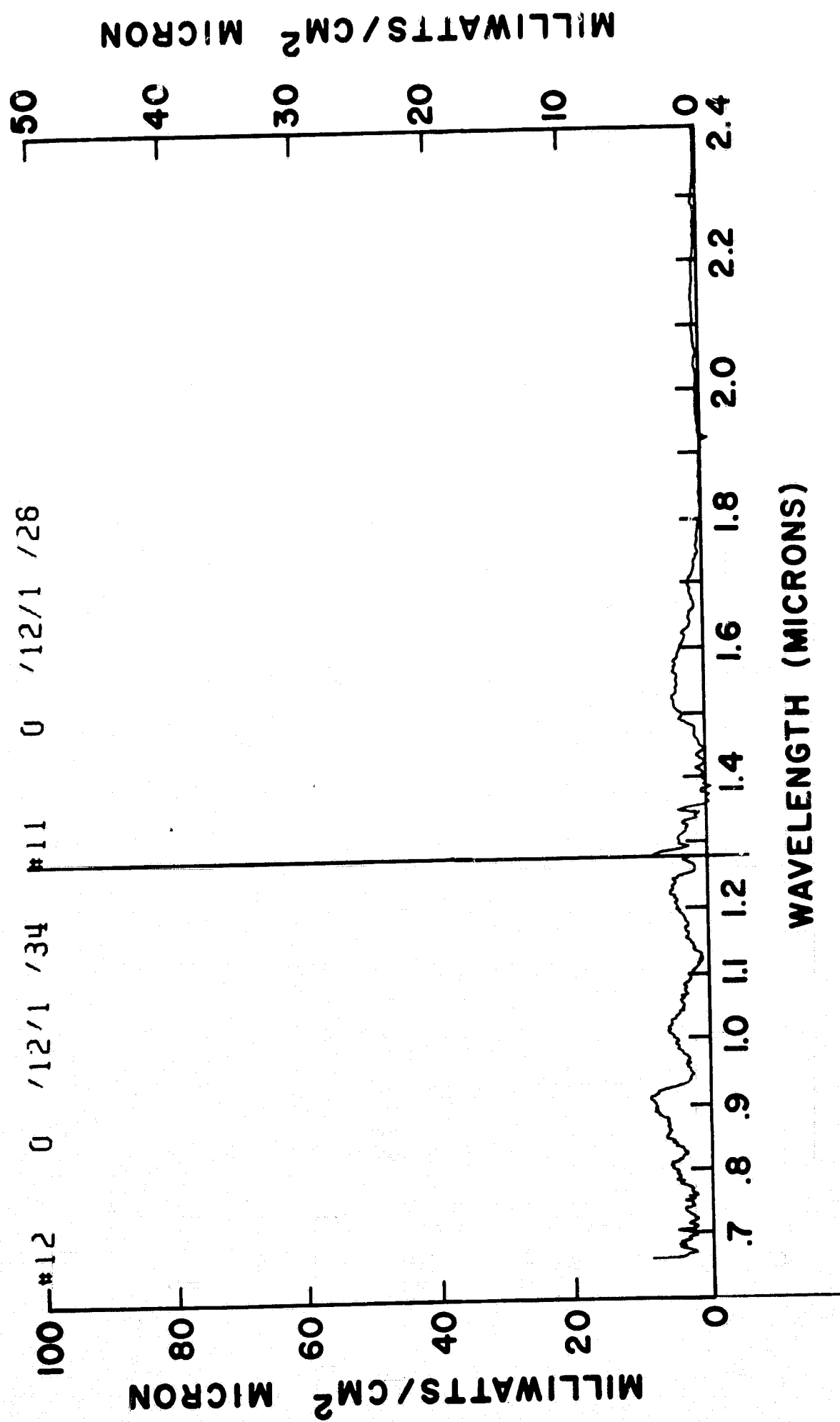
Spectrum Nos. Inclusive	Target	Location	Altitude kft
1-45	Patchy Kelp Beds	Coast between San Diego and Oceanside, Calif.	1
46-120	Red Tide	Coast between Ocean- side and Laguna, Calif.	1
121-124	Clear Ocean	Coast N of Laguna Calif.	1
125-143	Red Tide	S of Laguna, Calif.	1

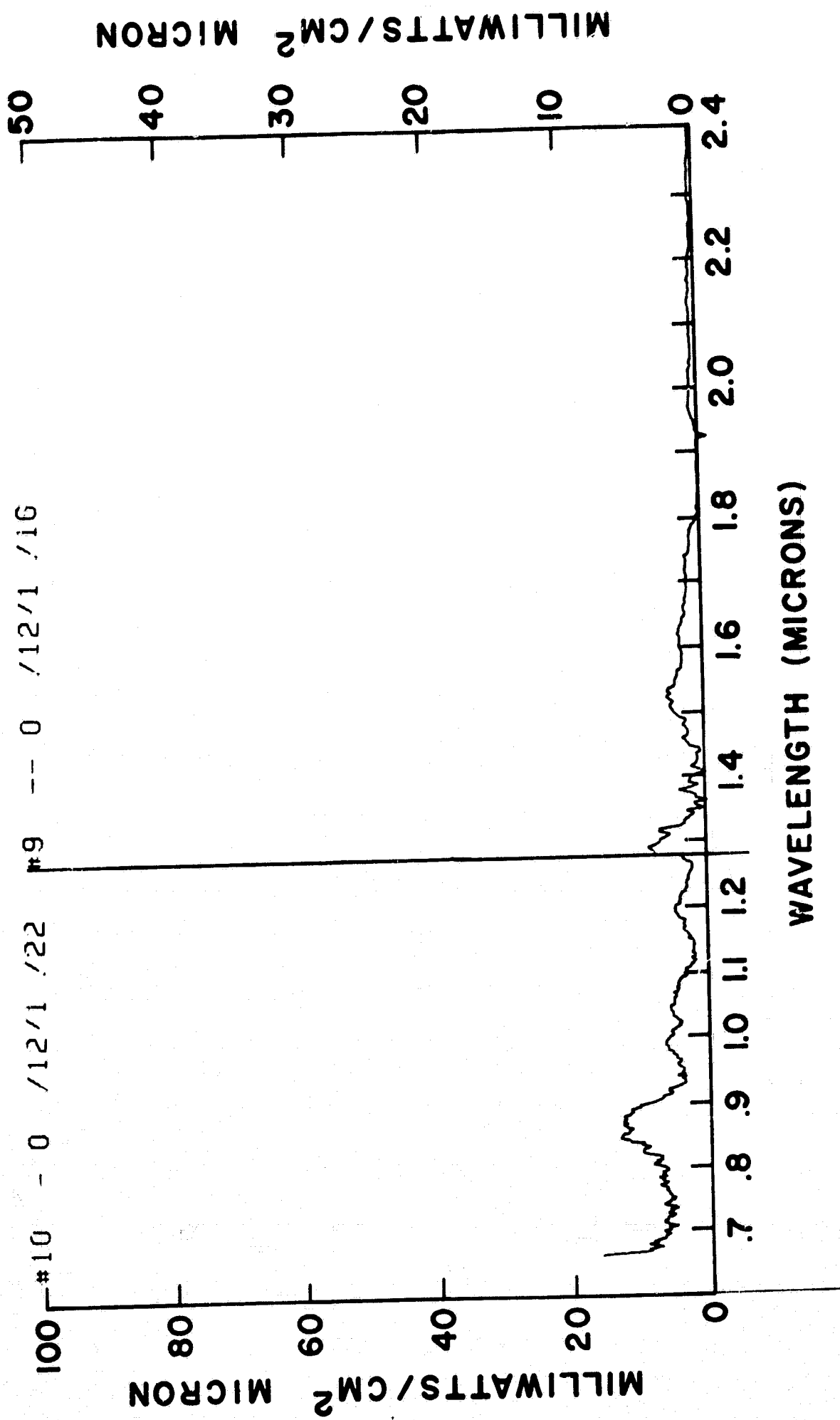


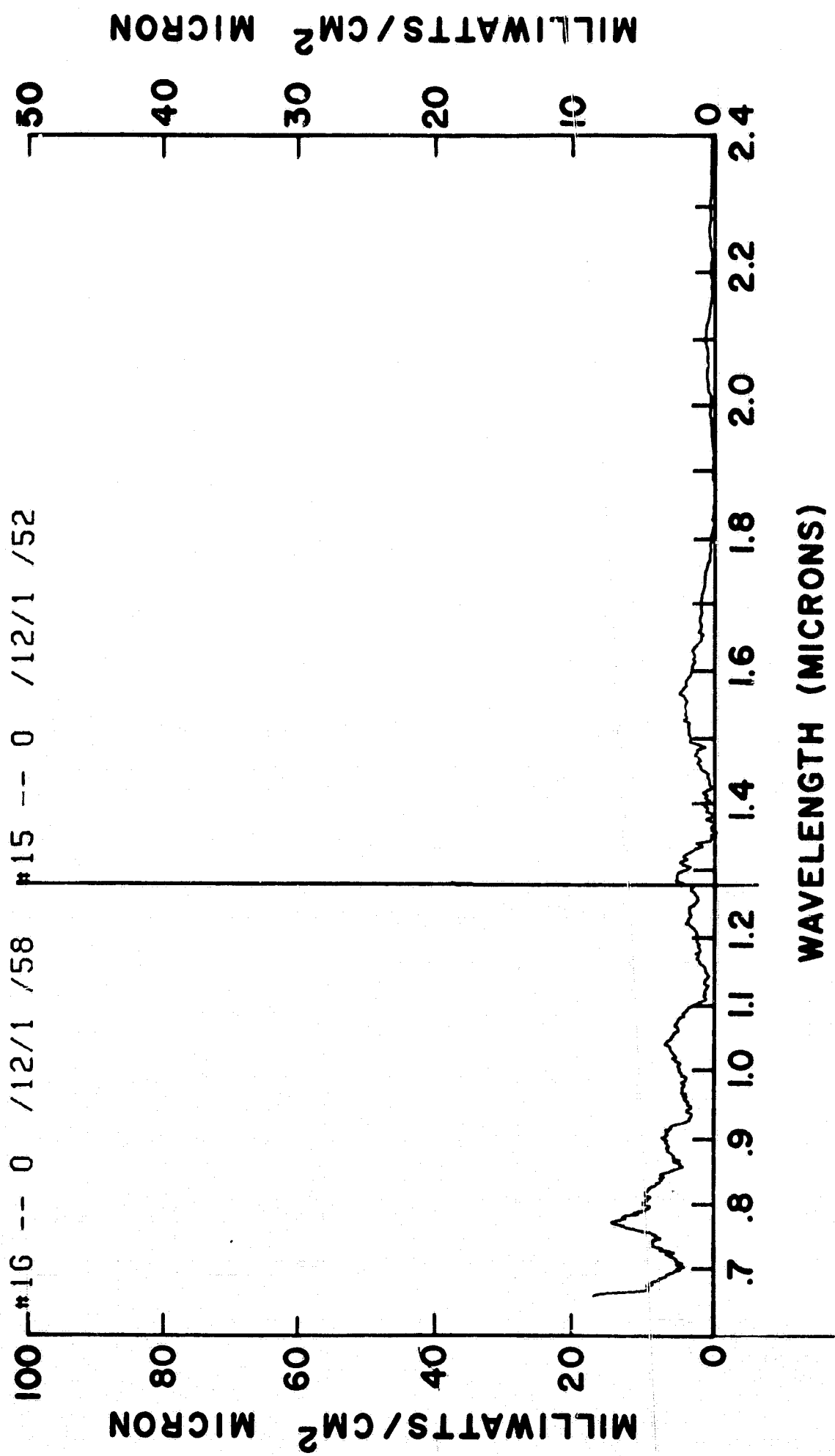


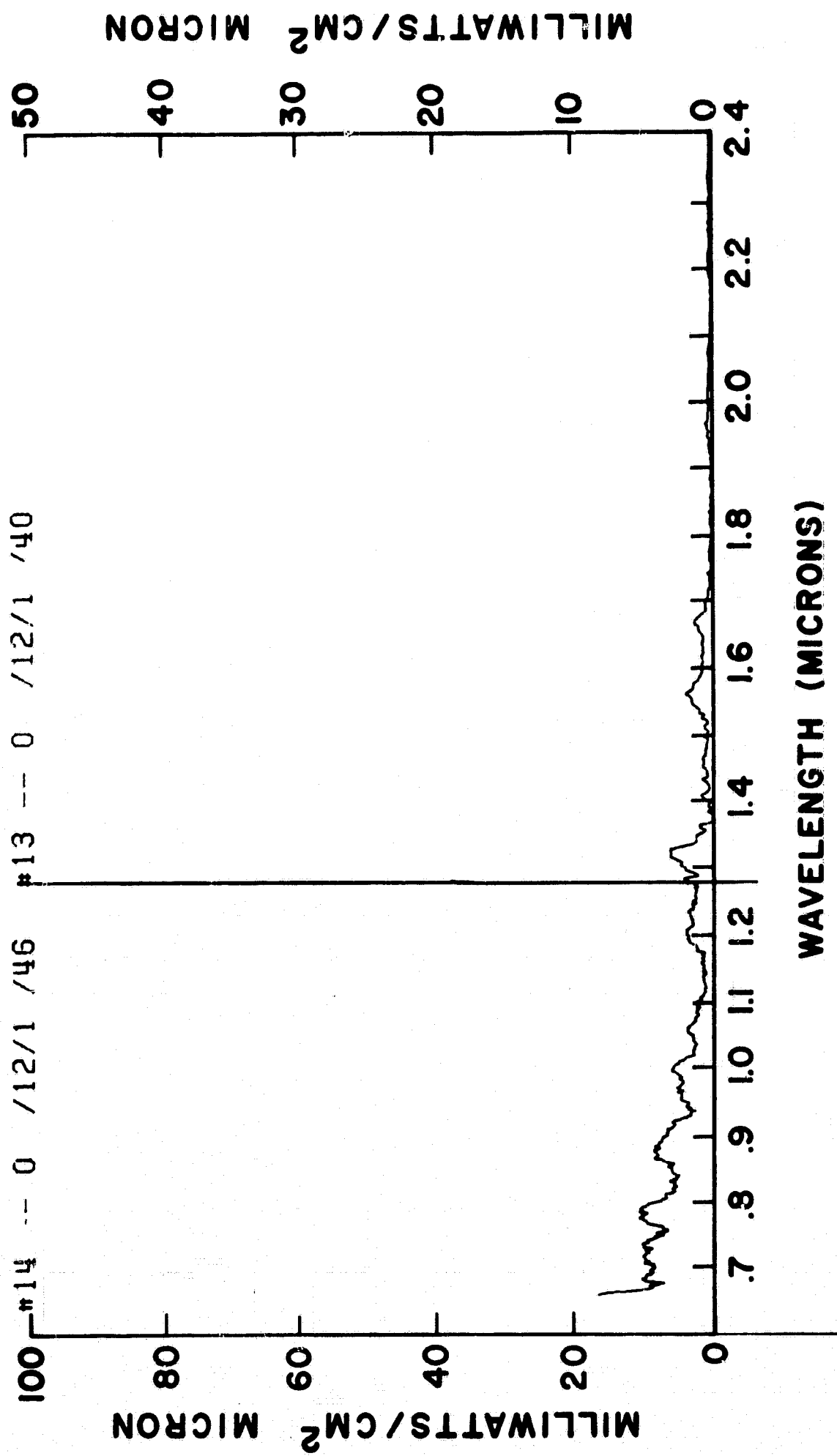


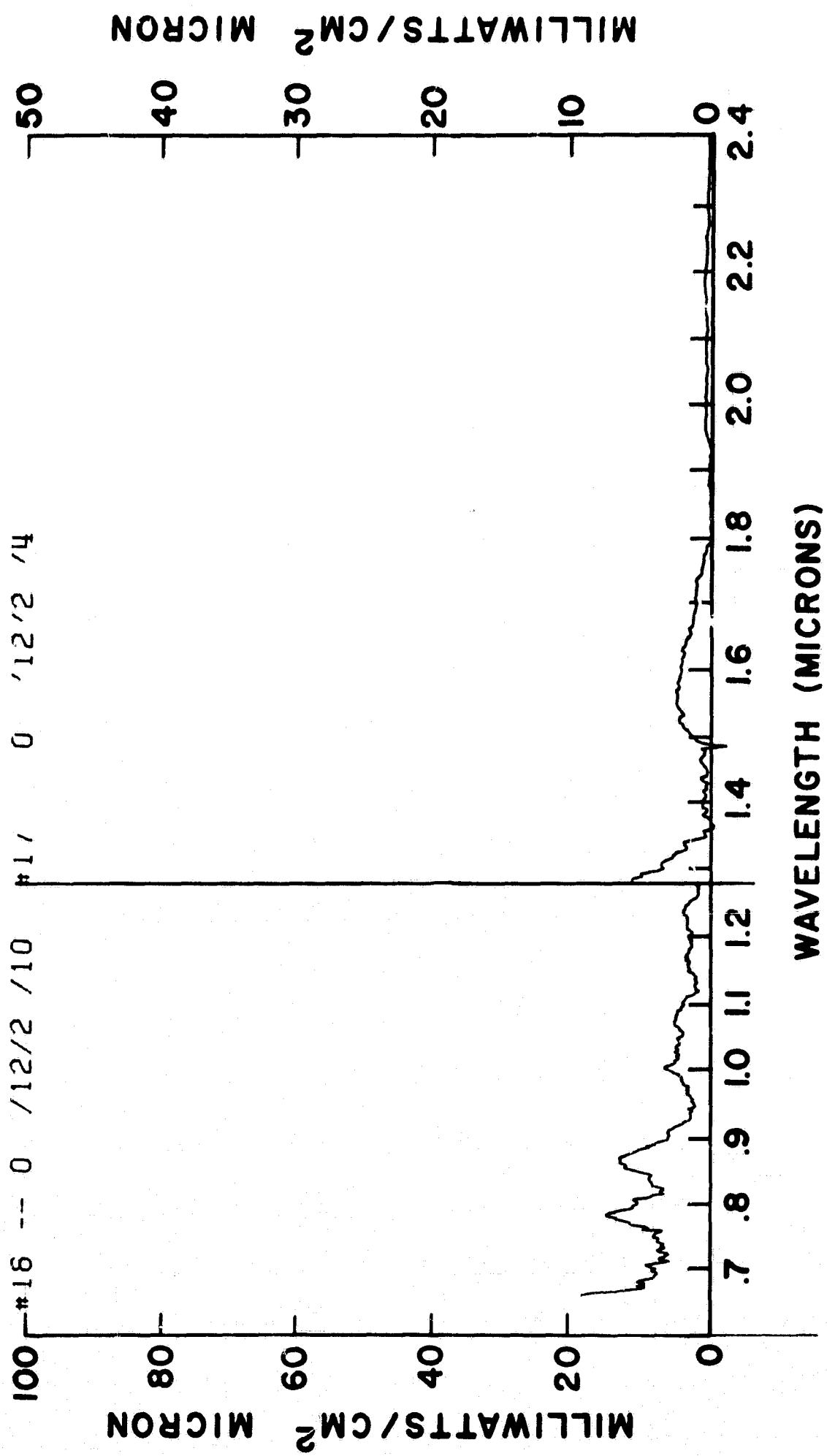


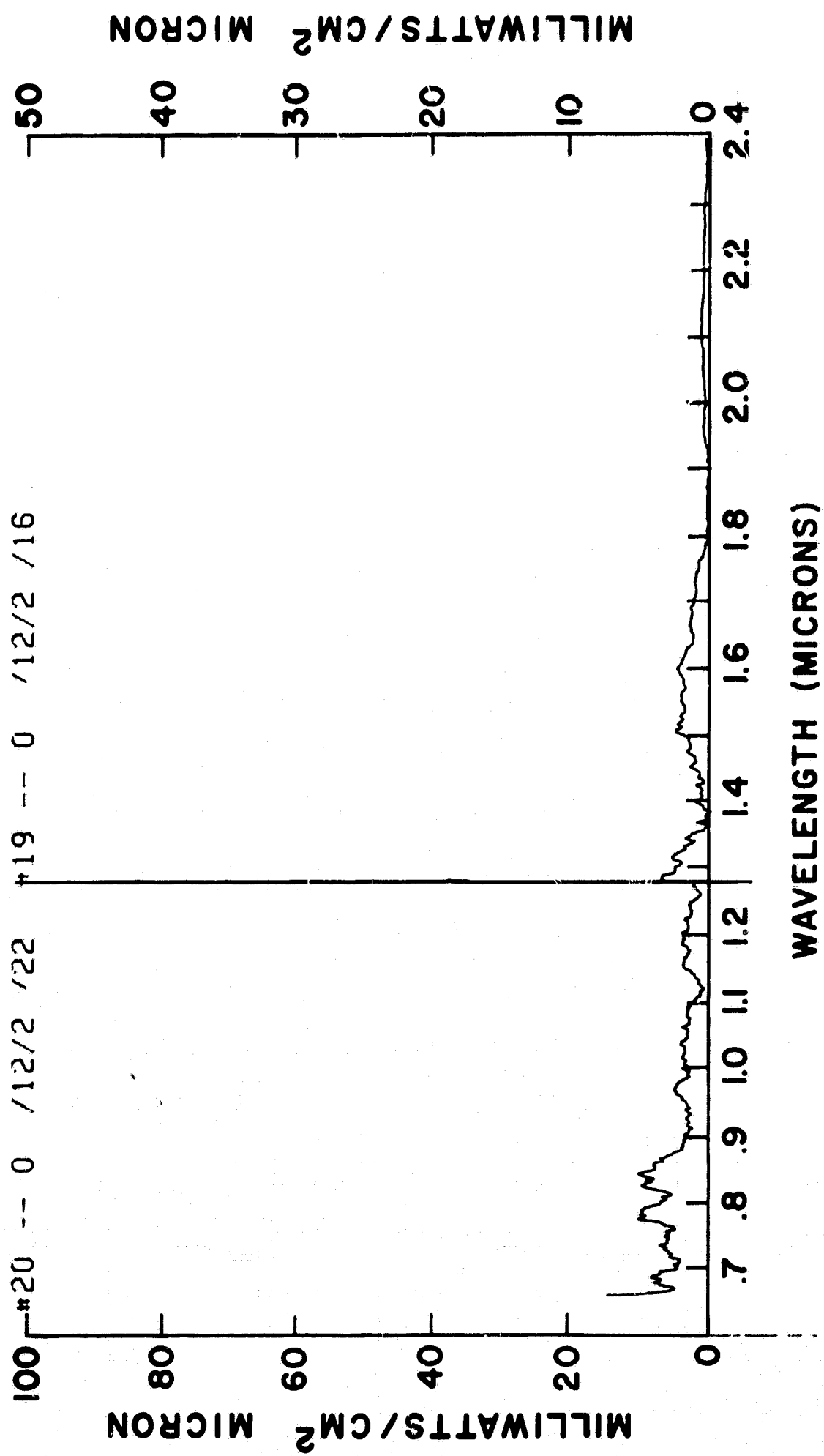


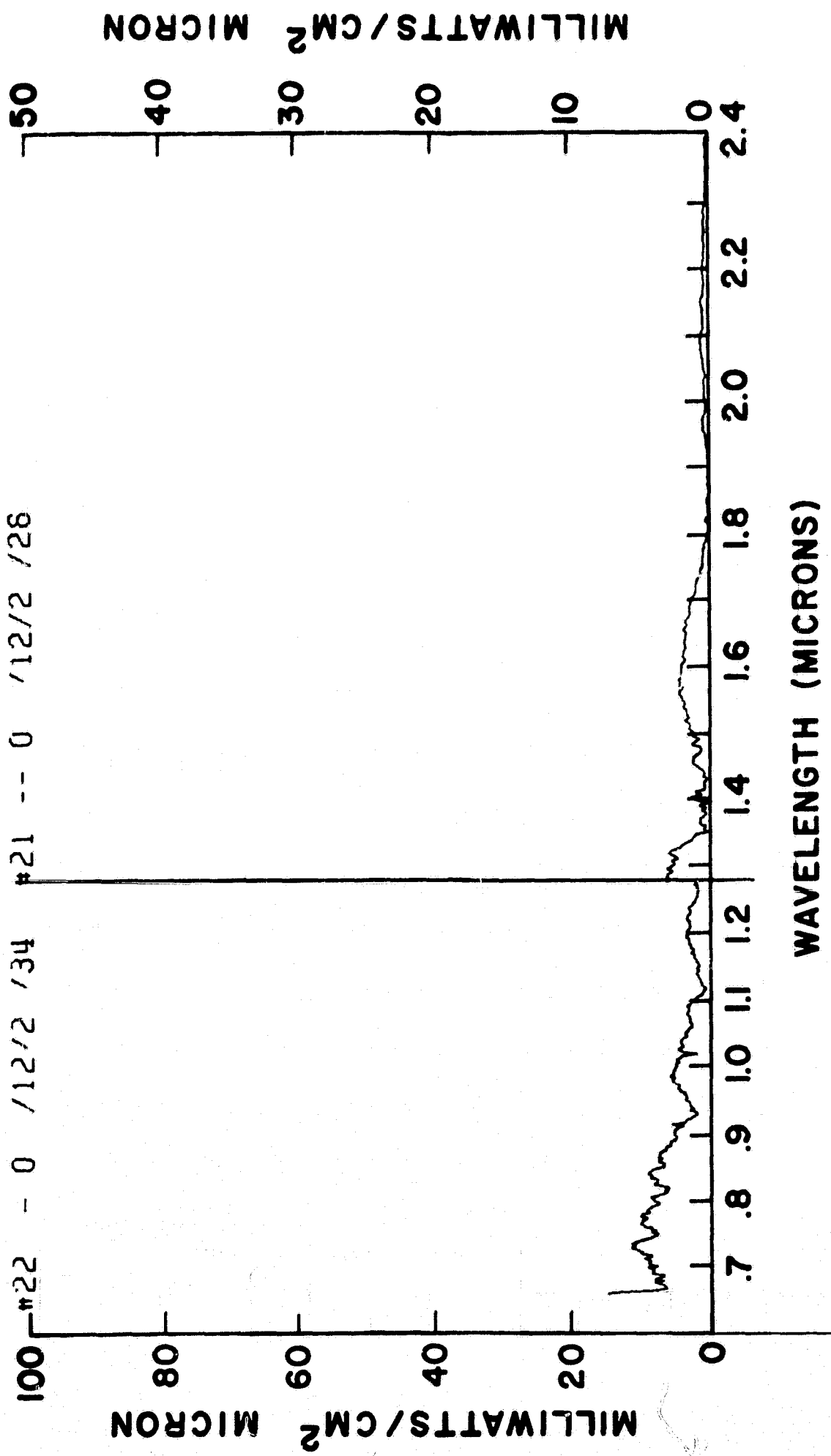


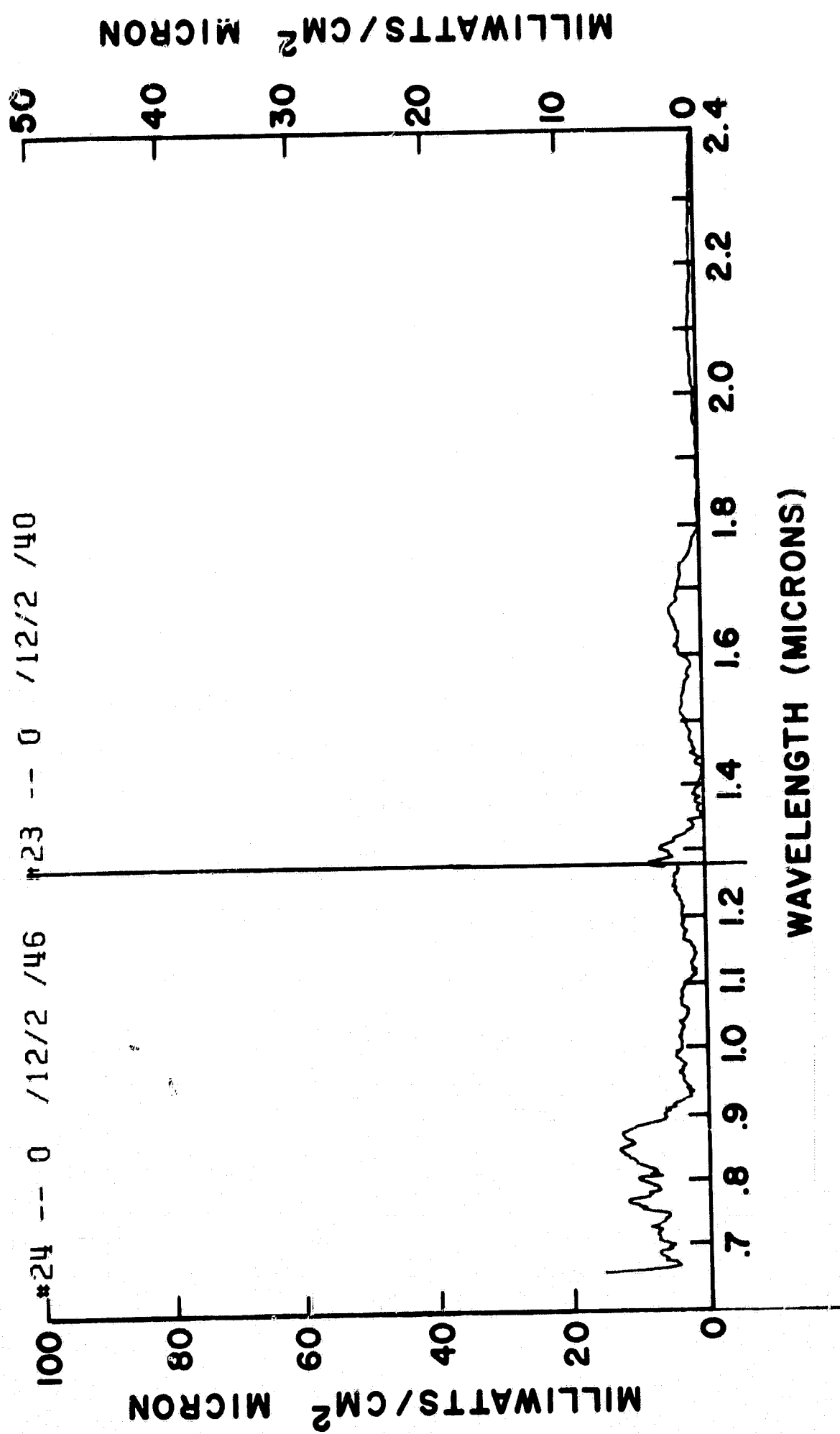


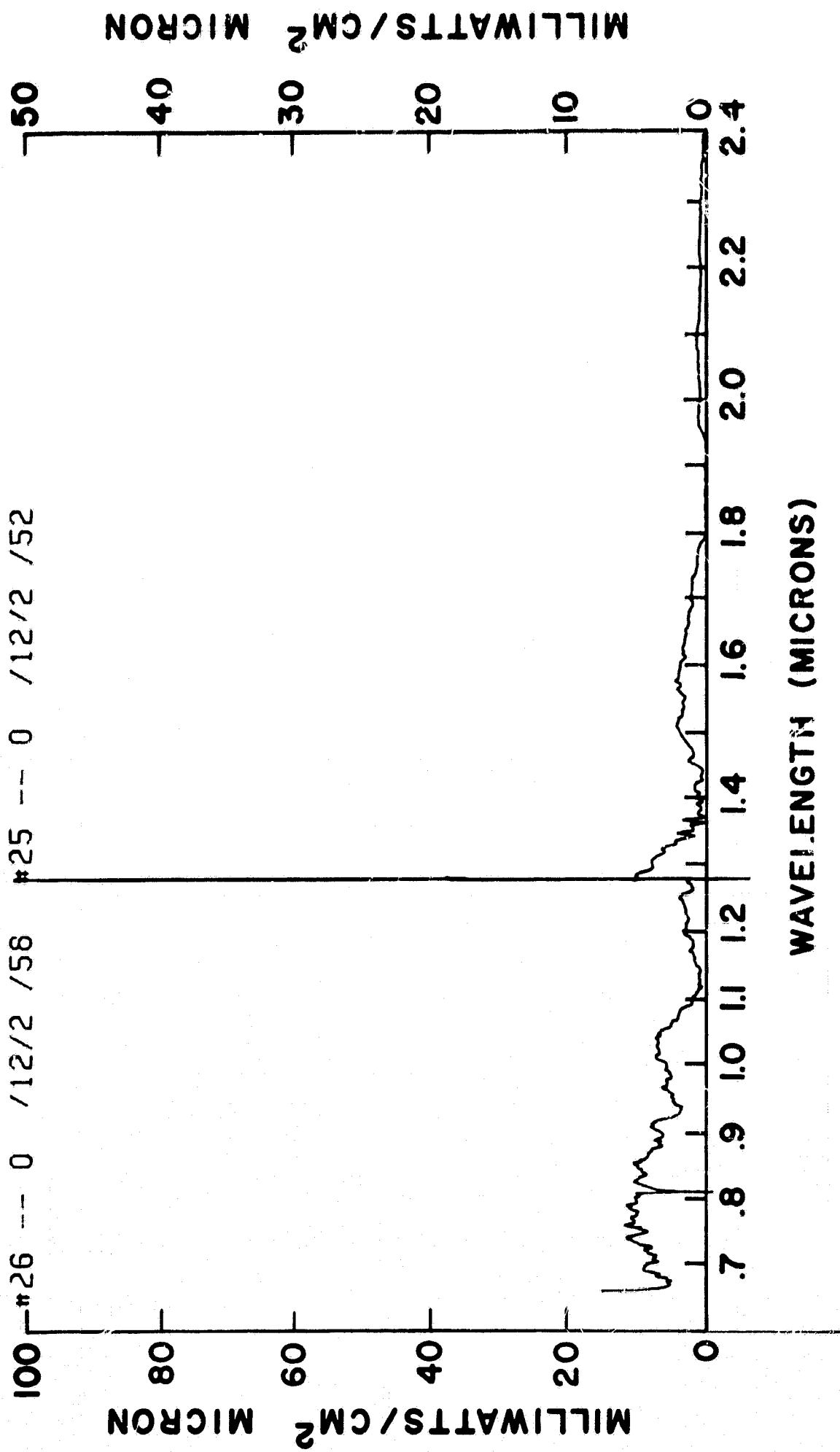


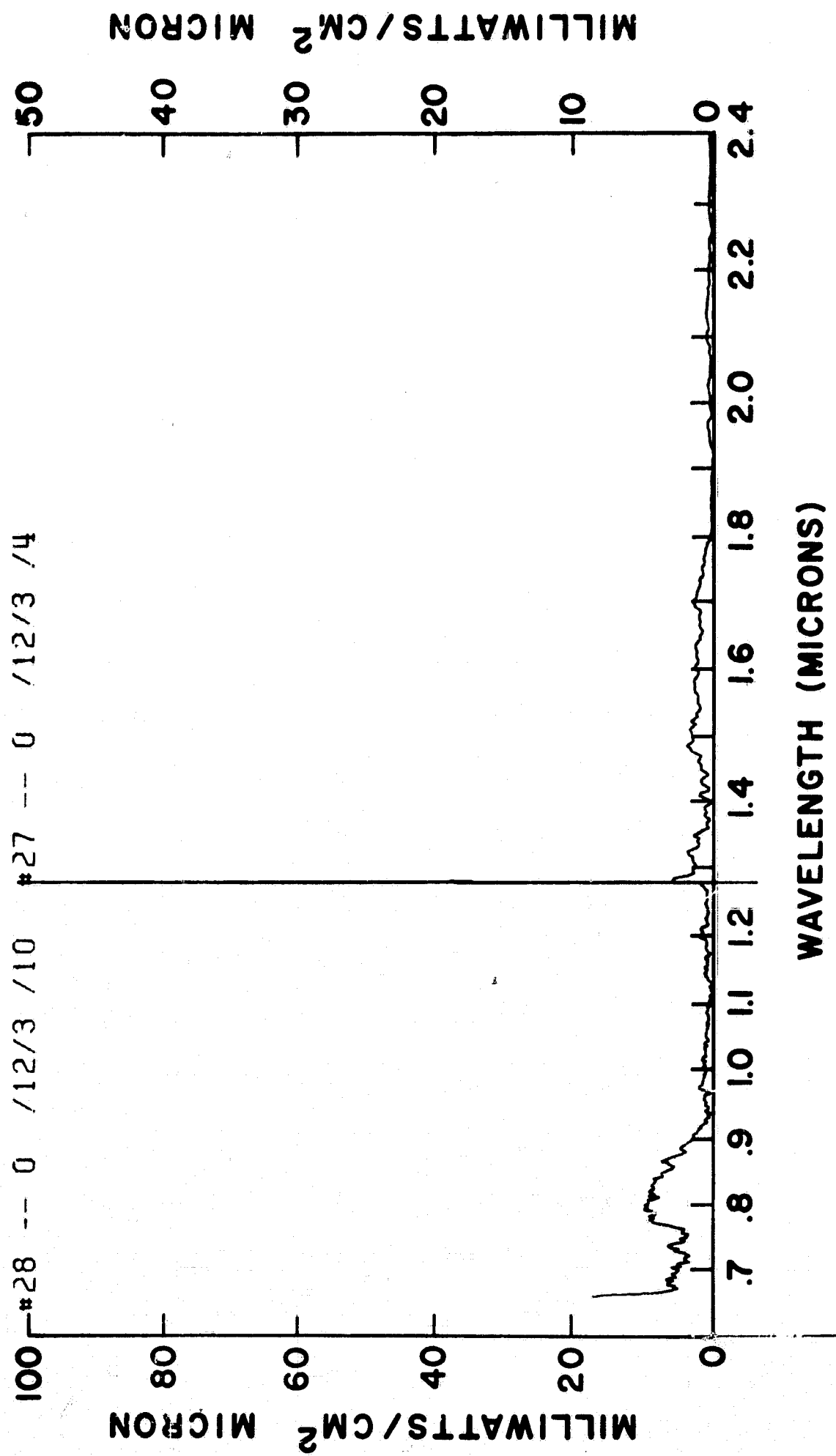


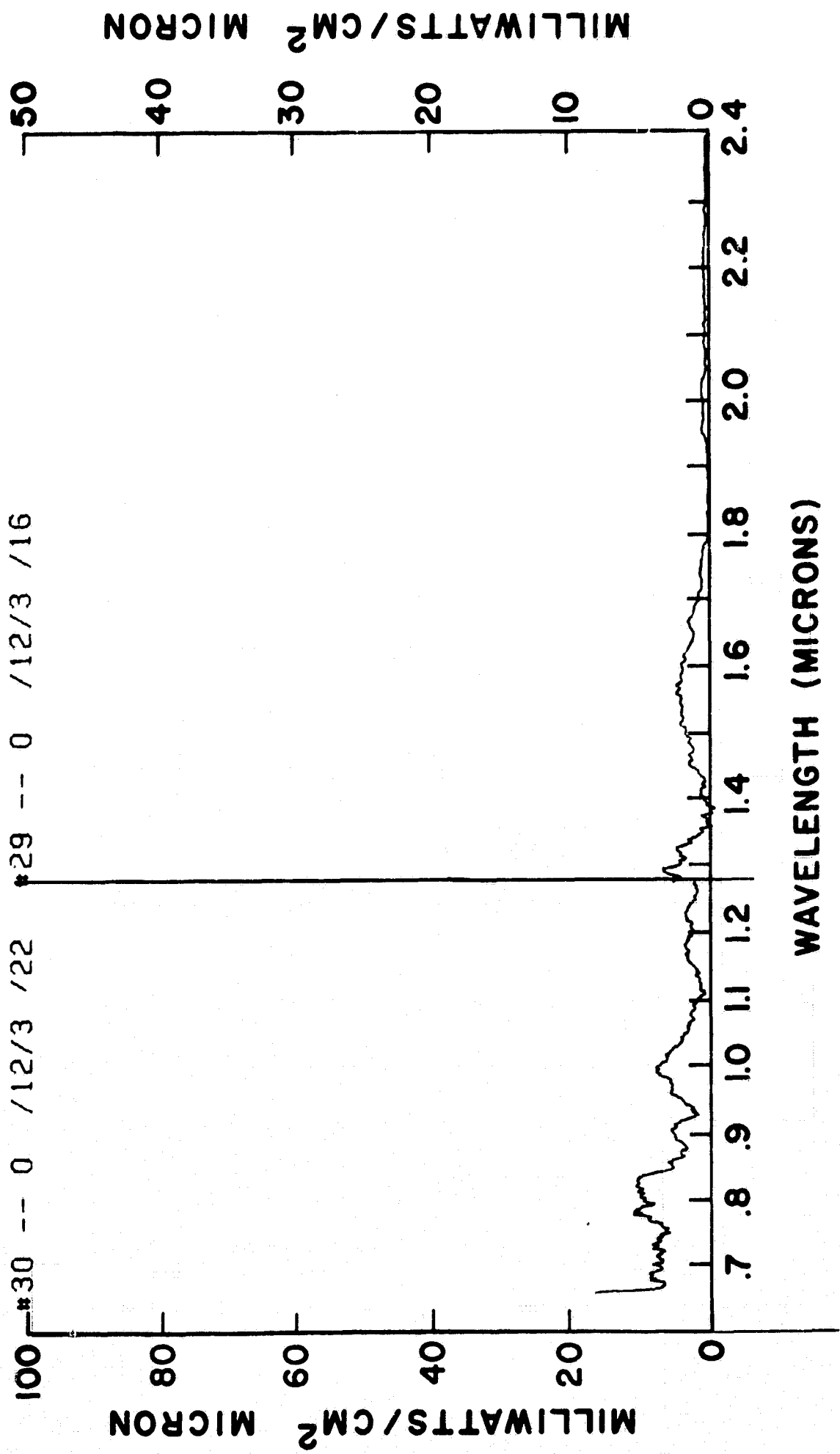


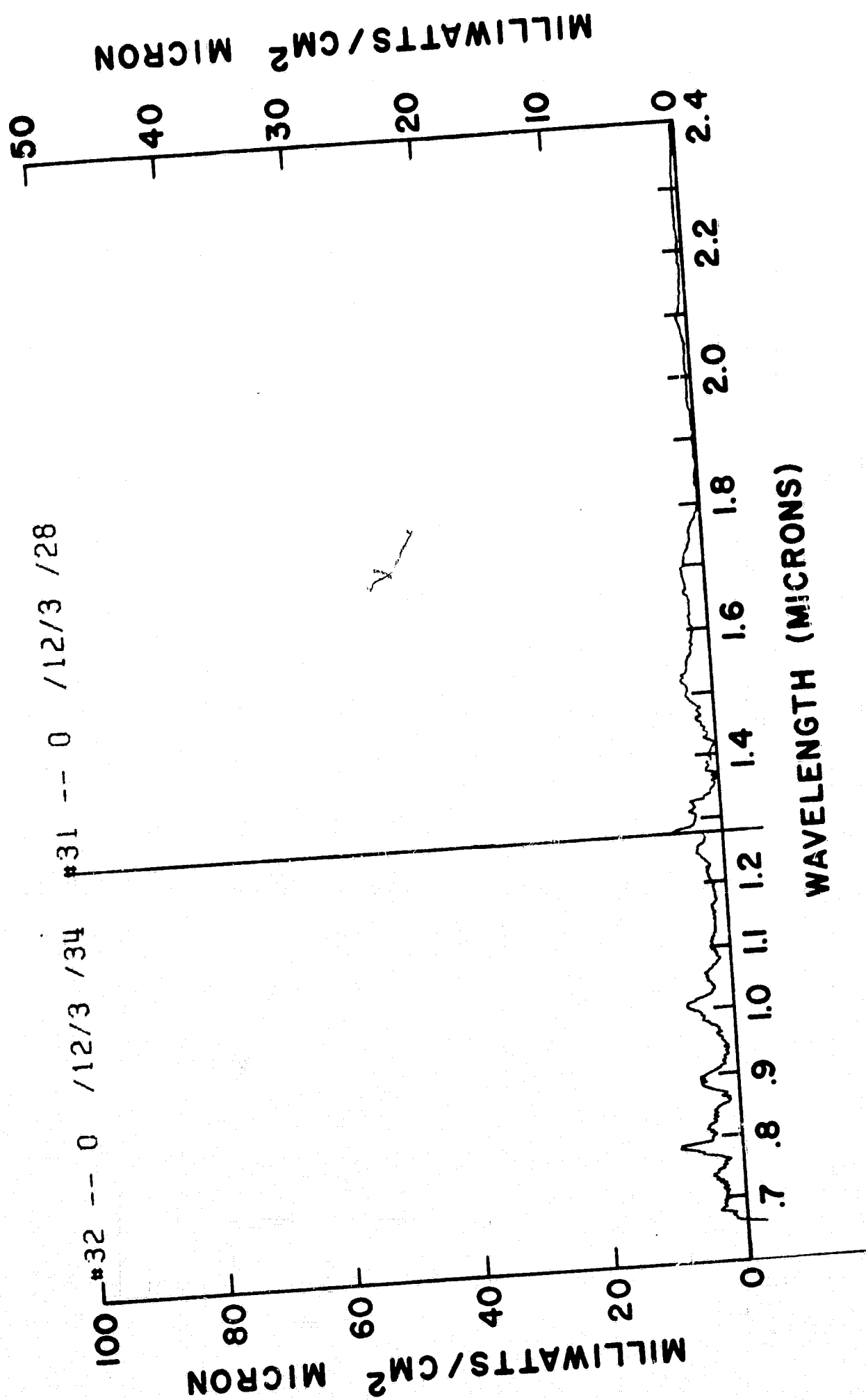


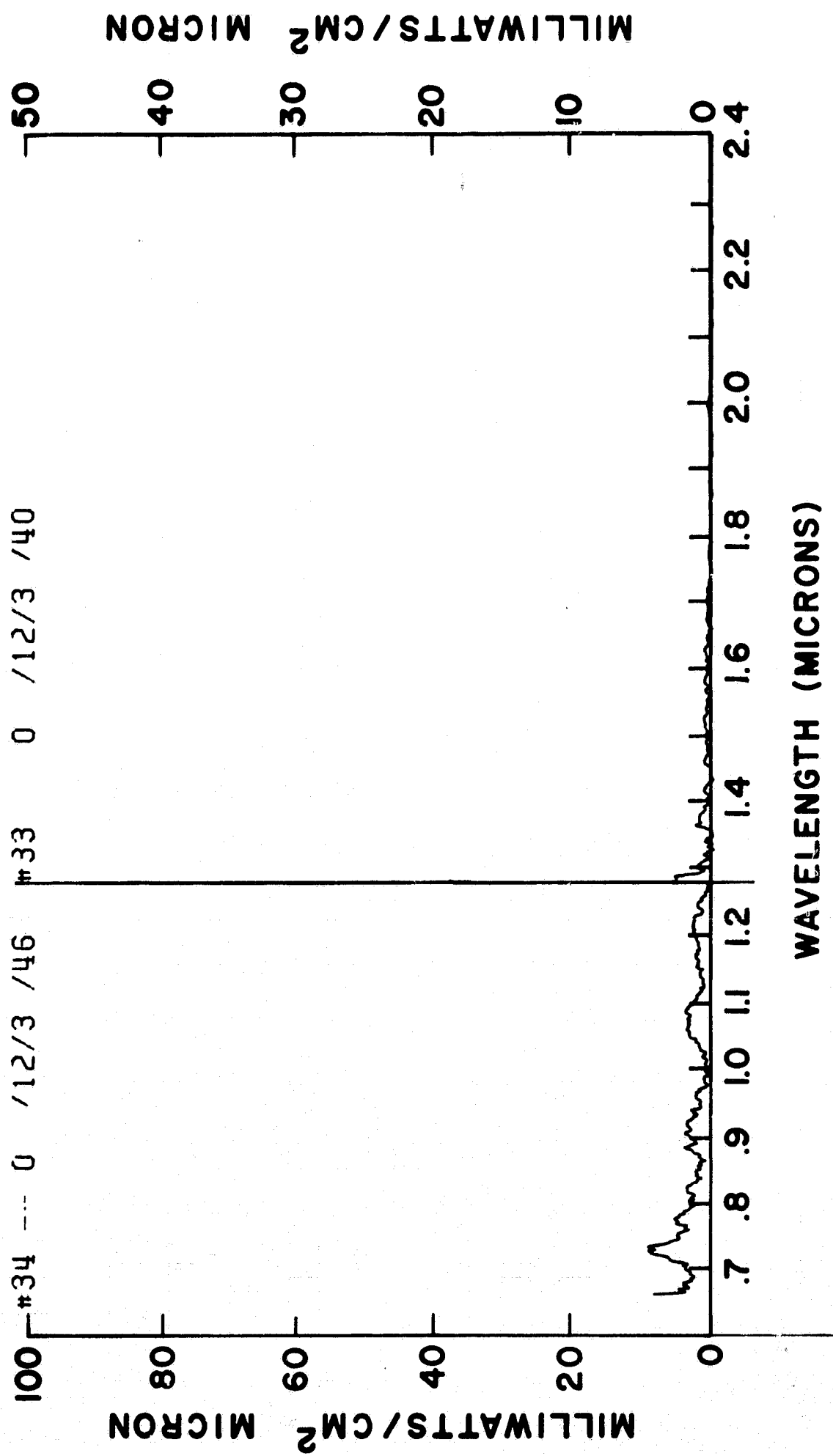


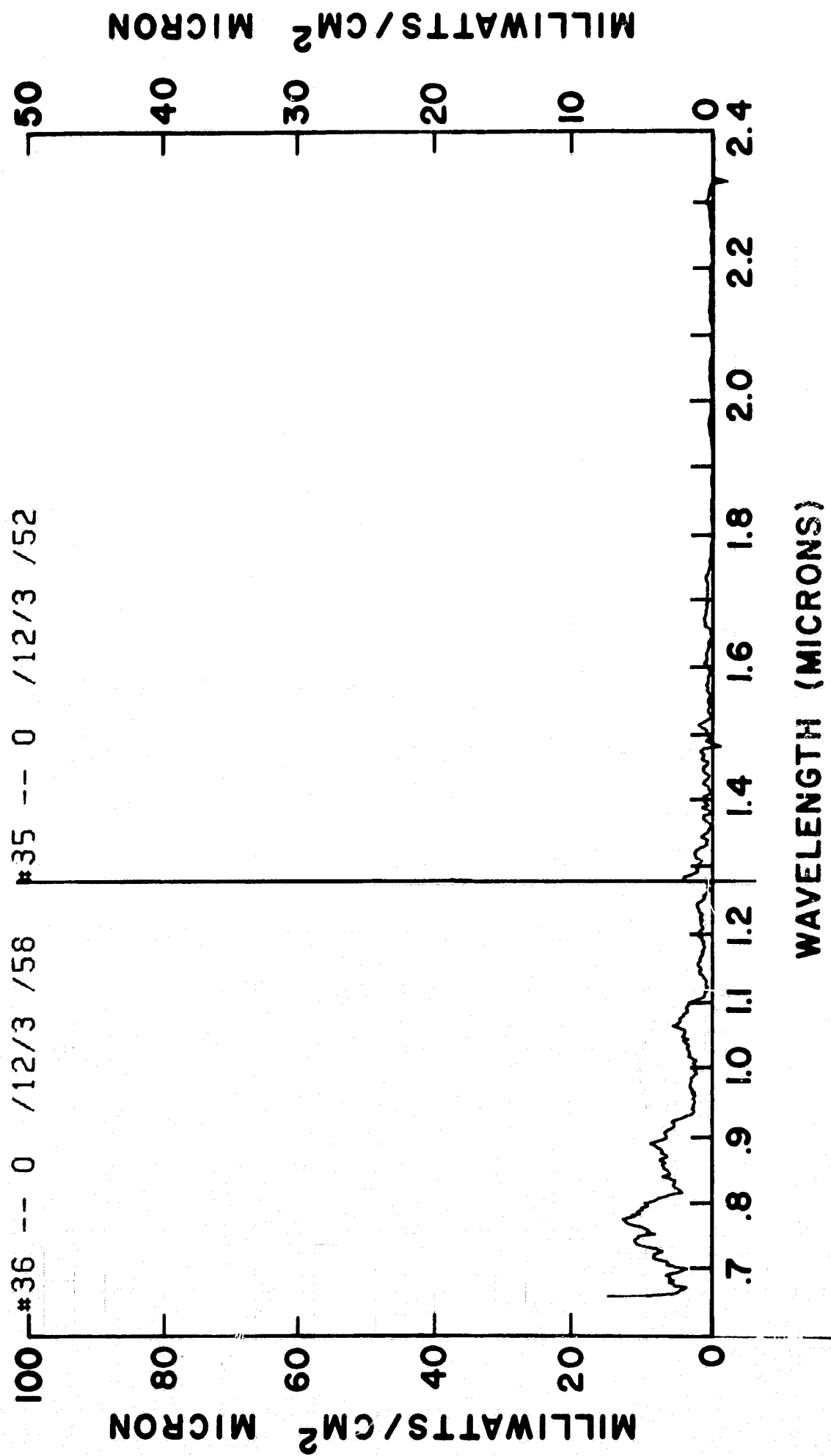


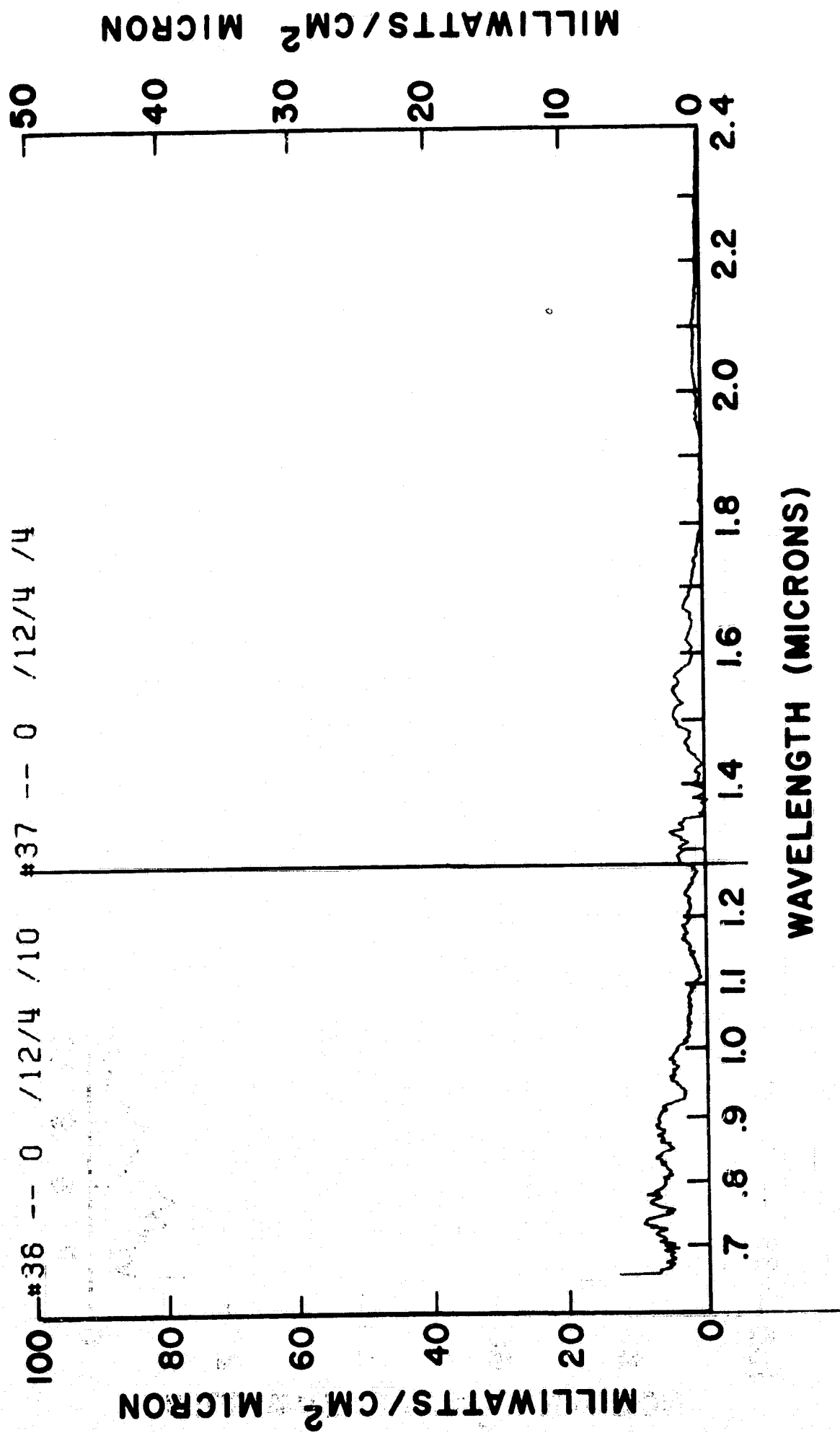


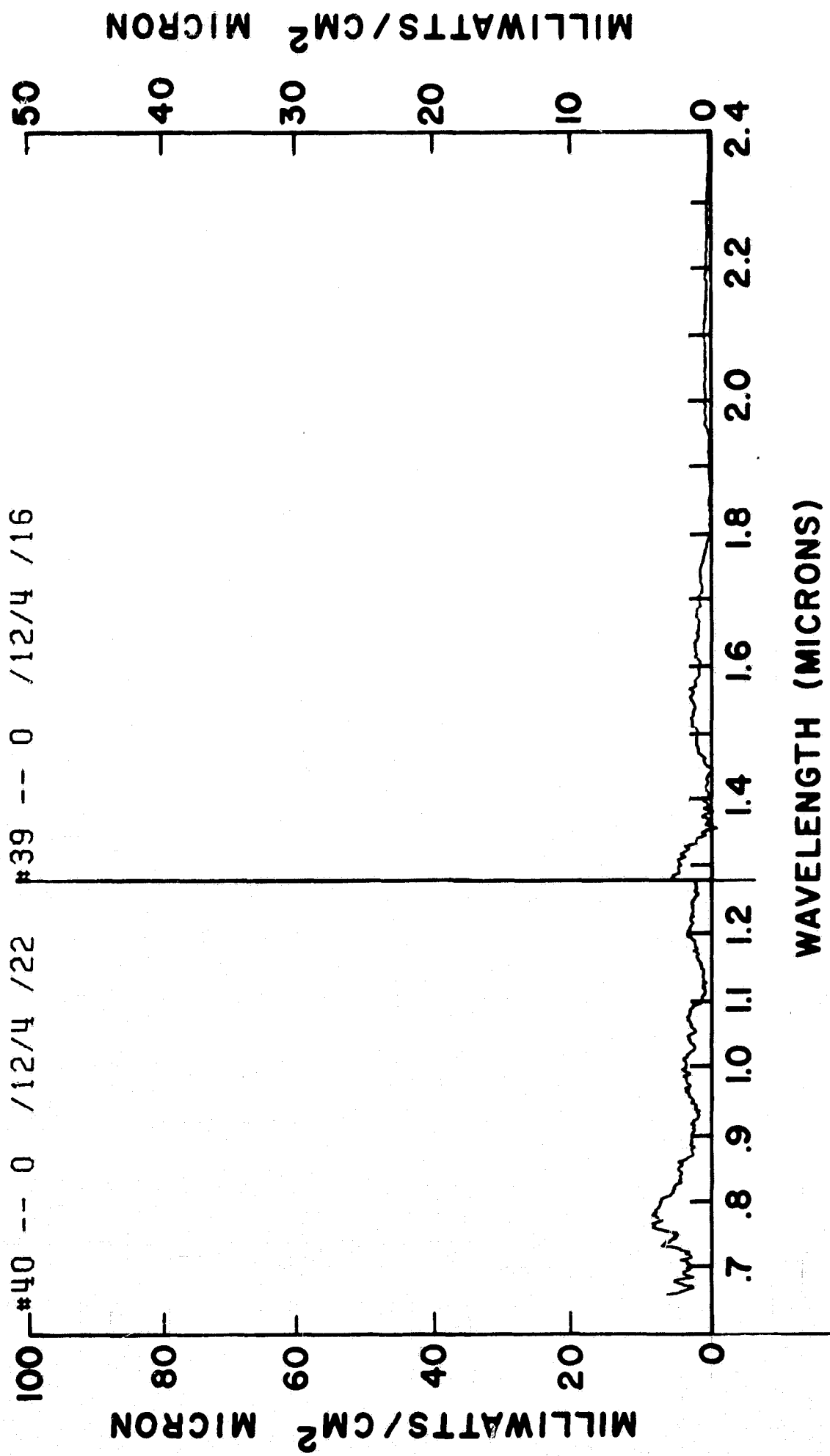


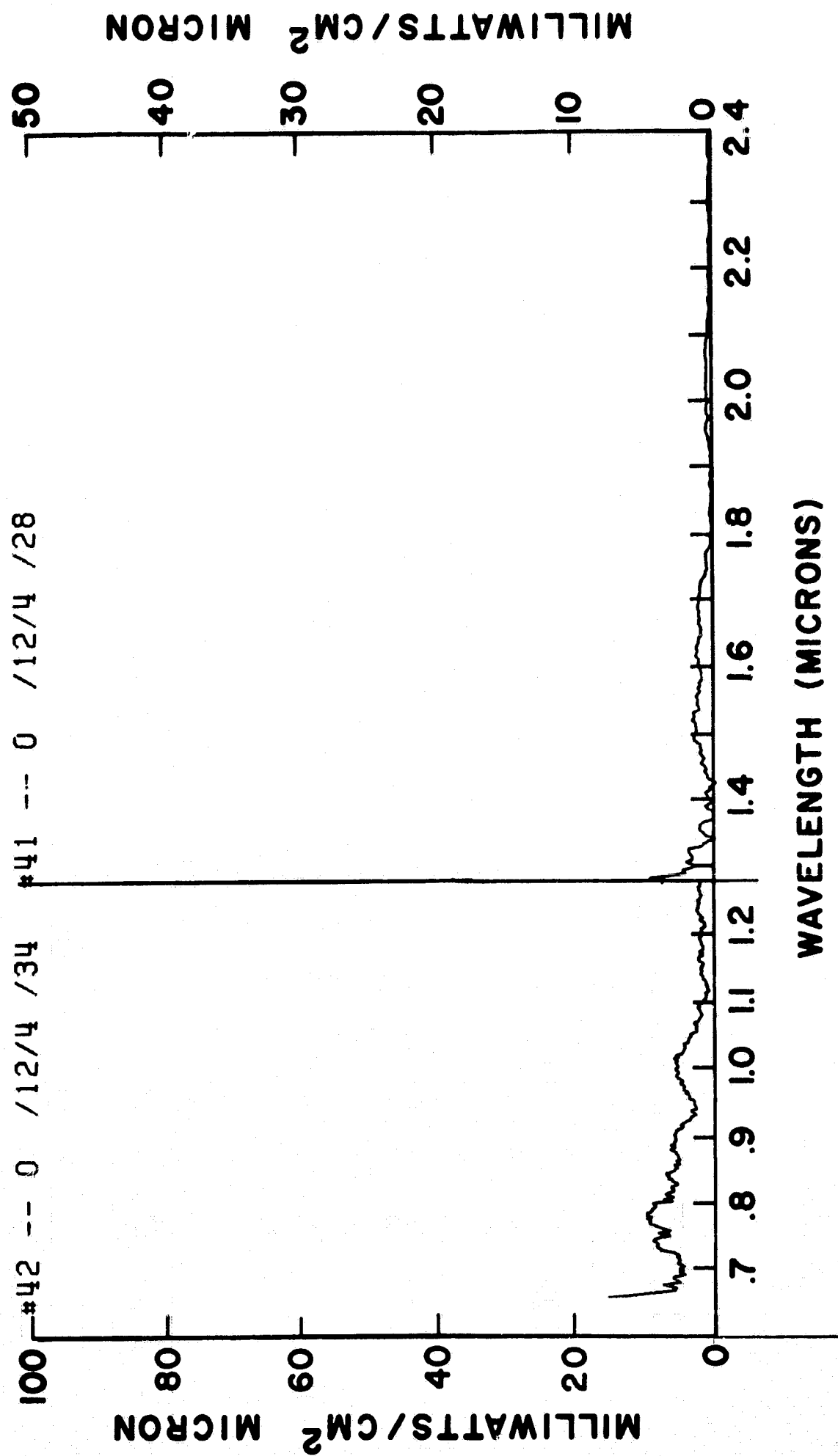


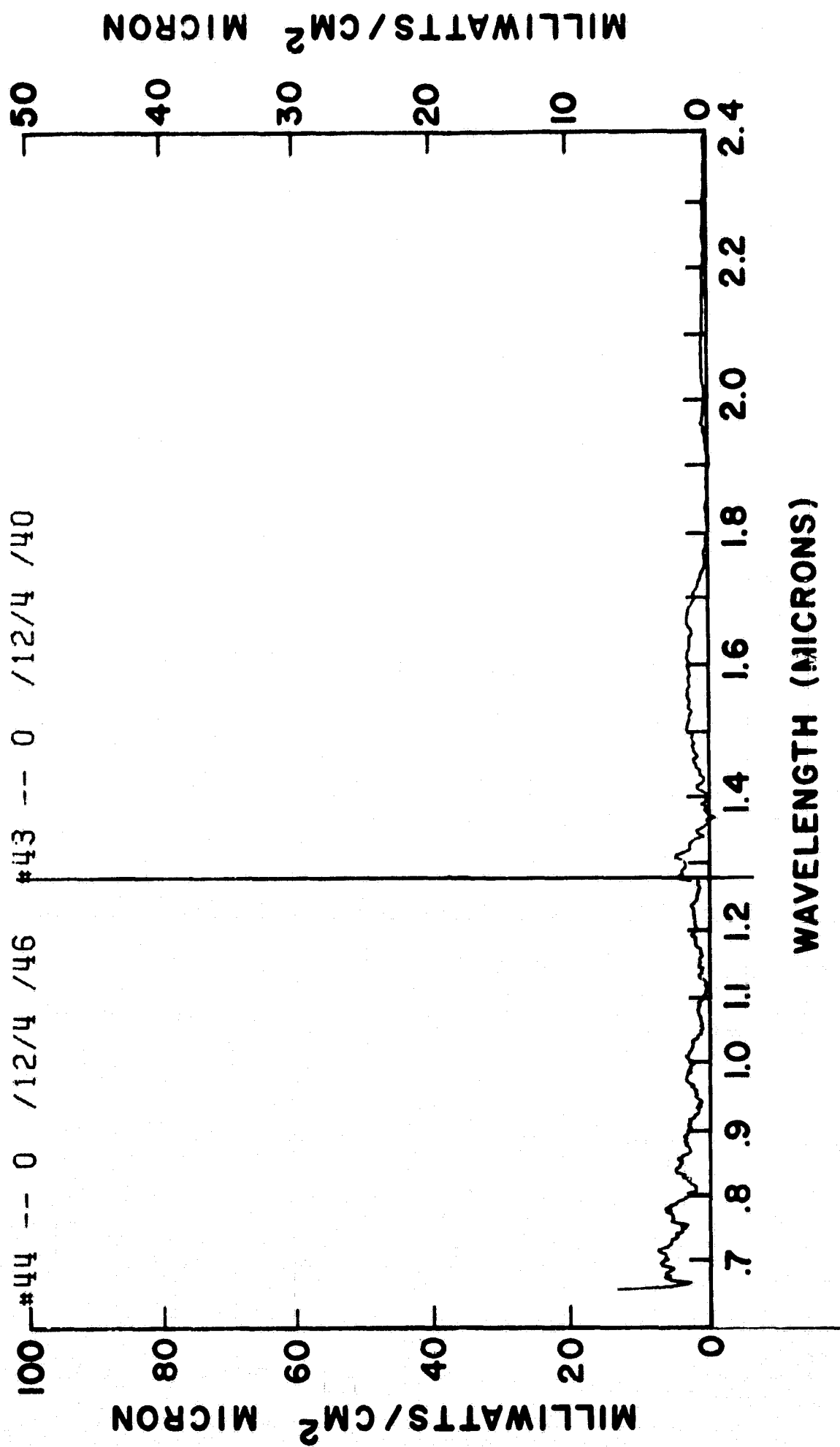


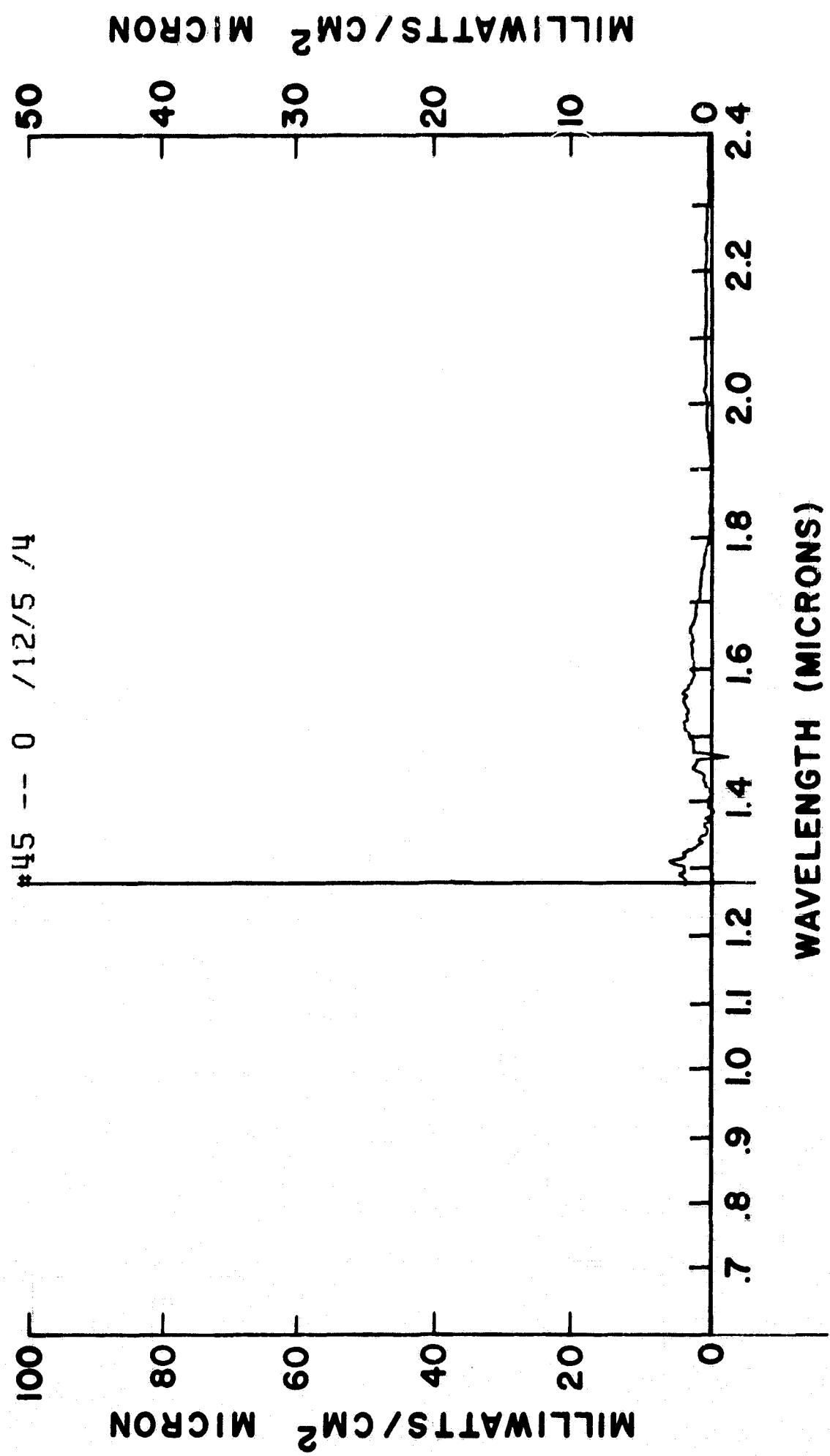


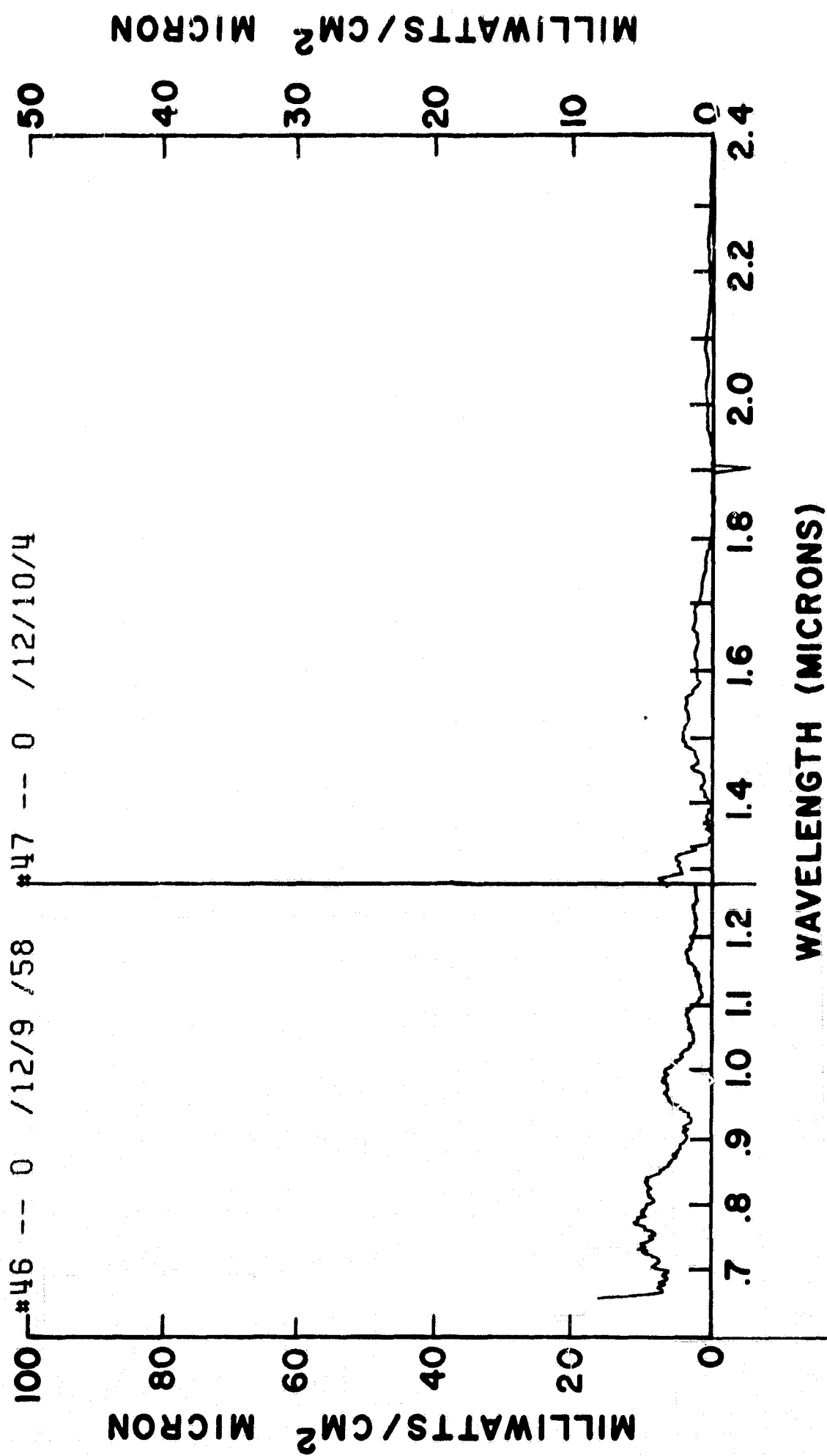


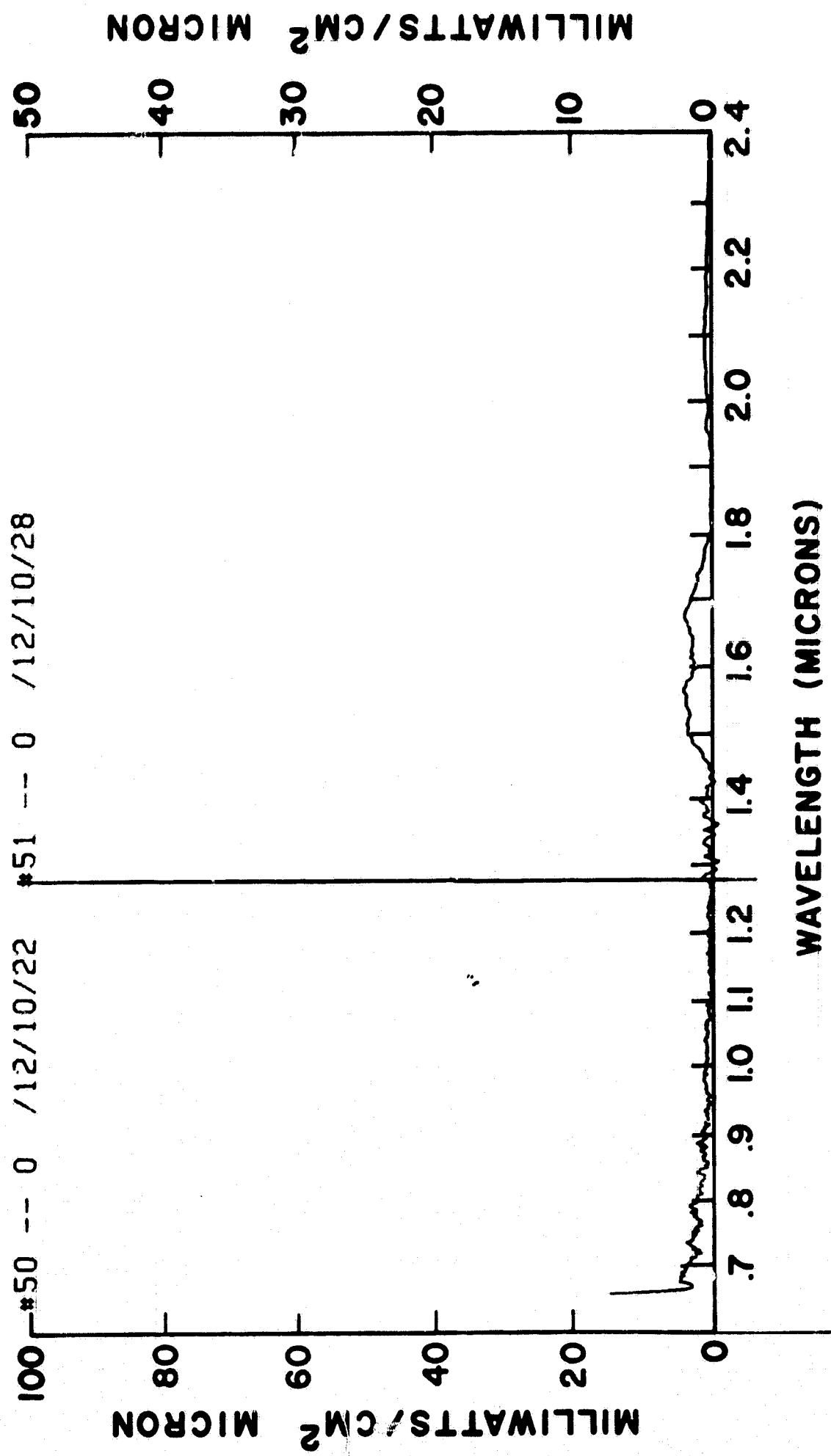


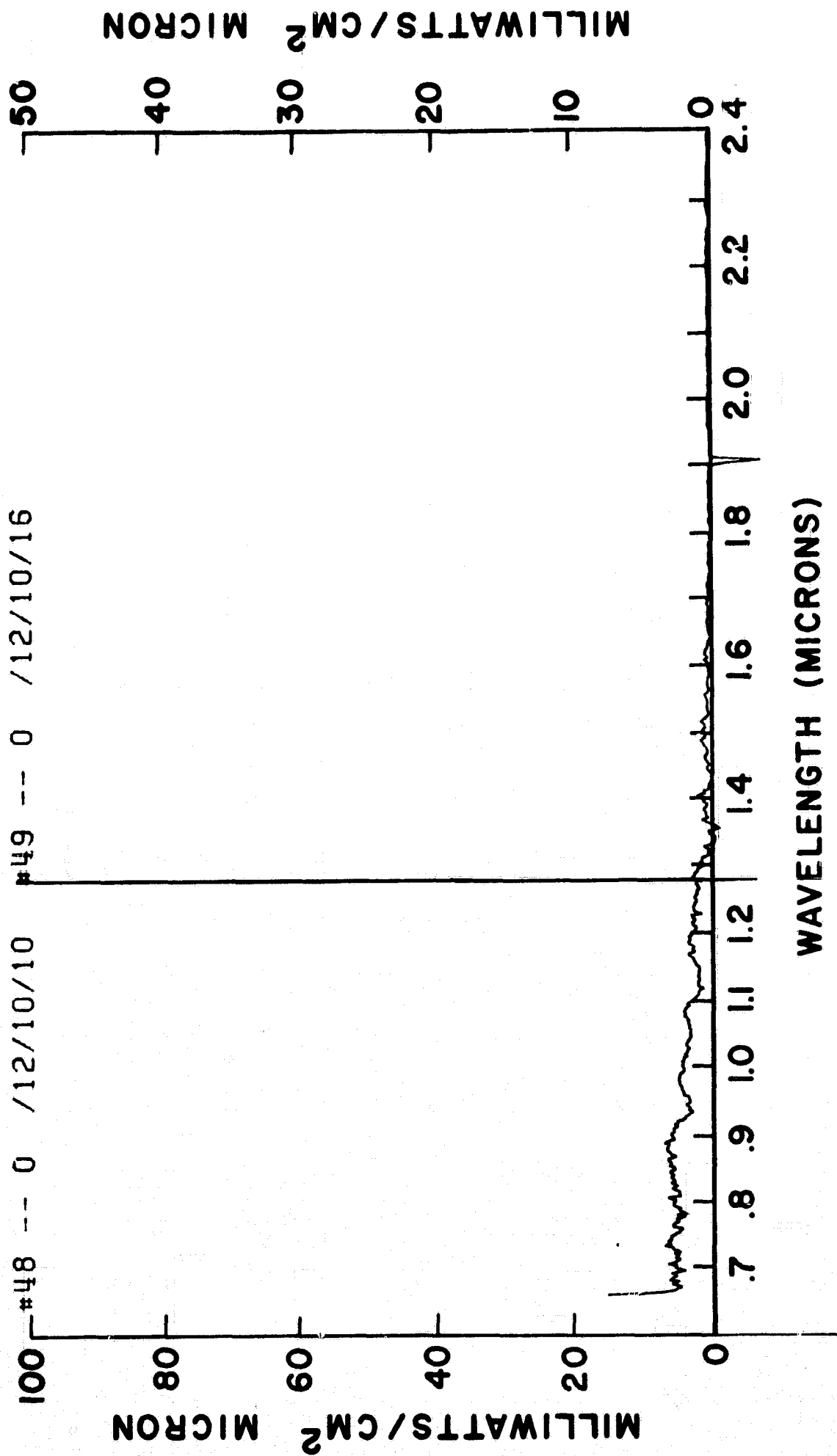


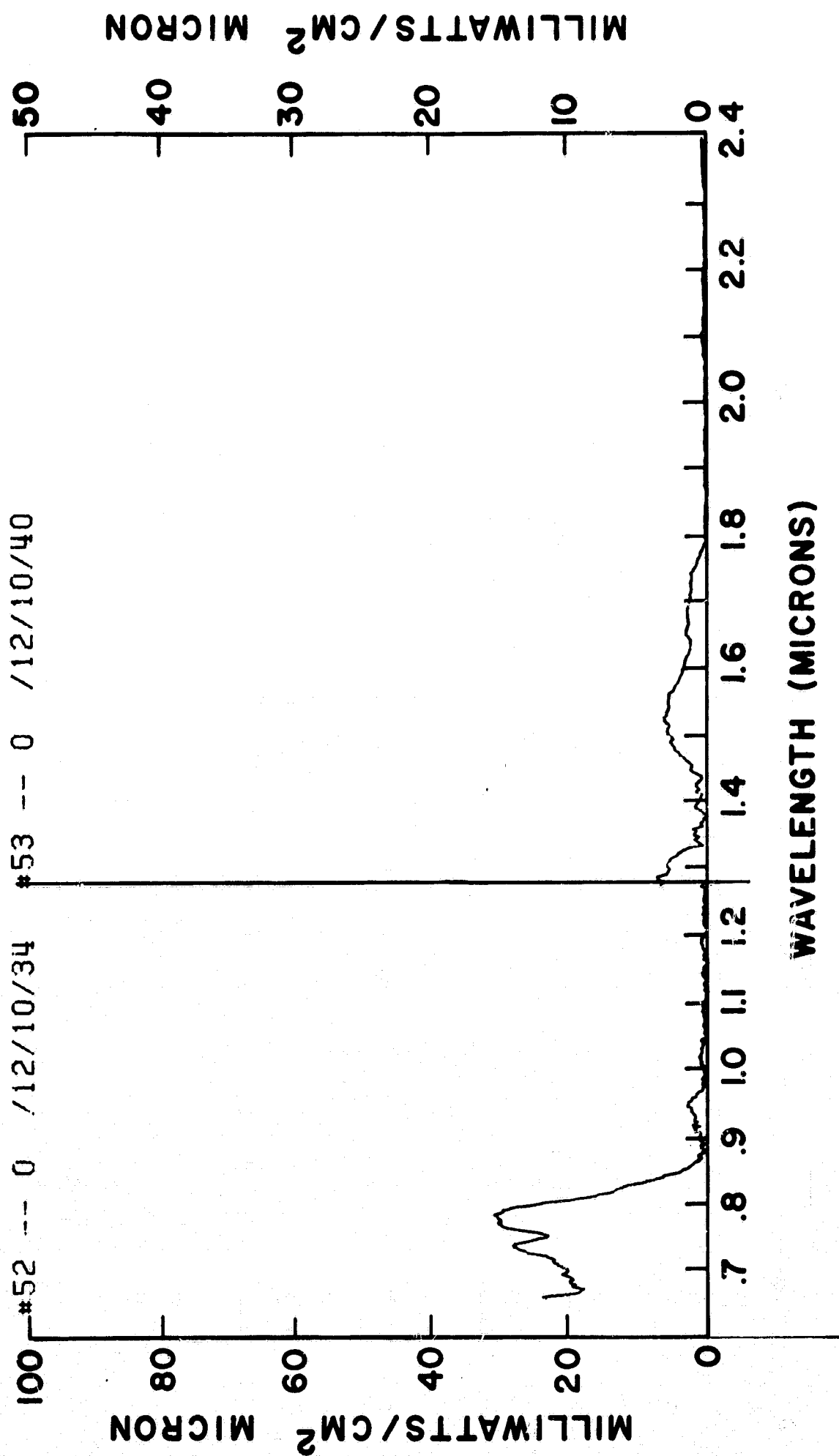


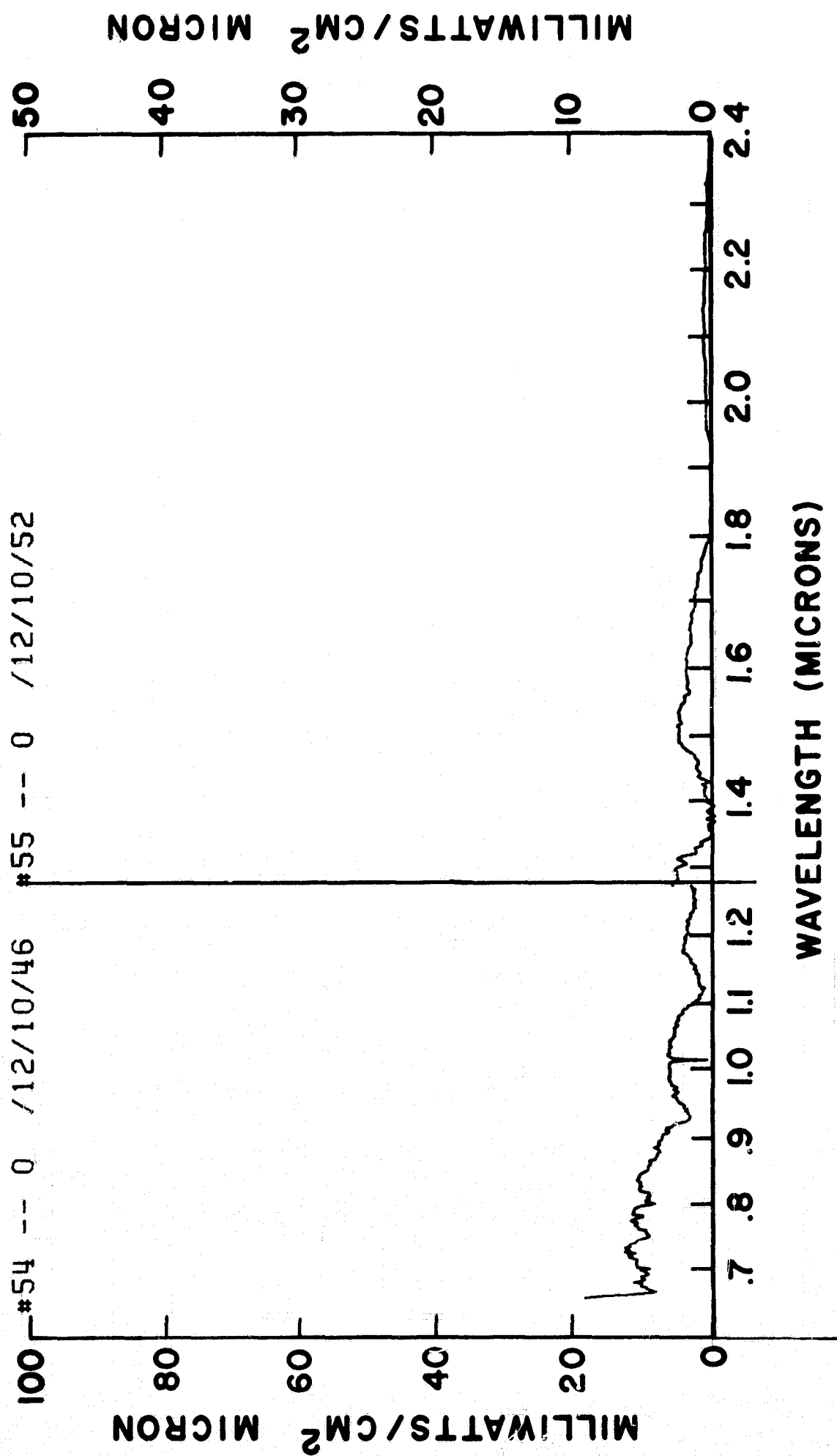


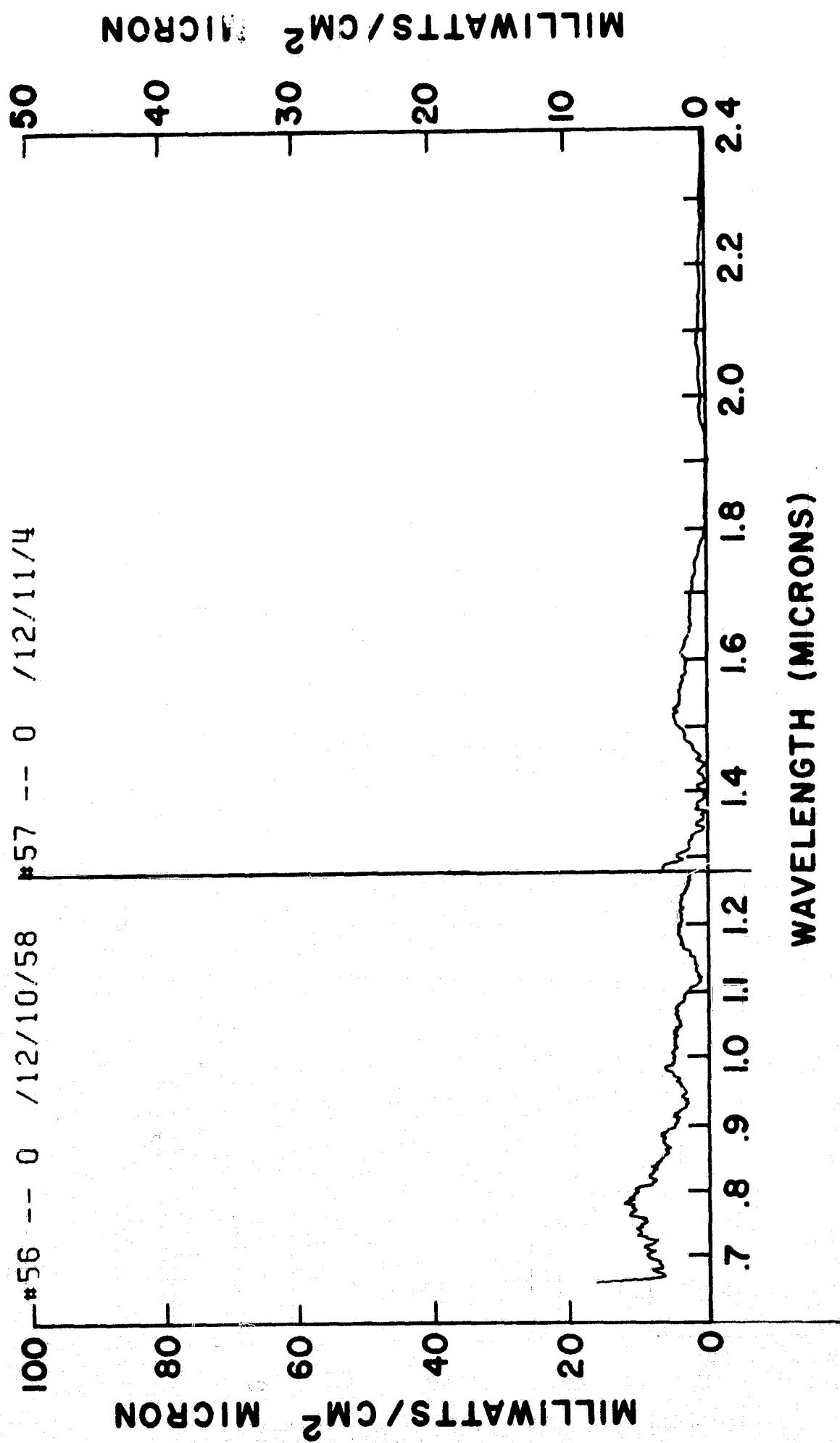


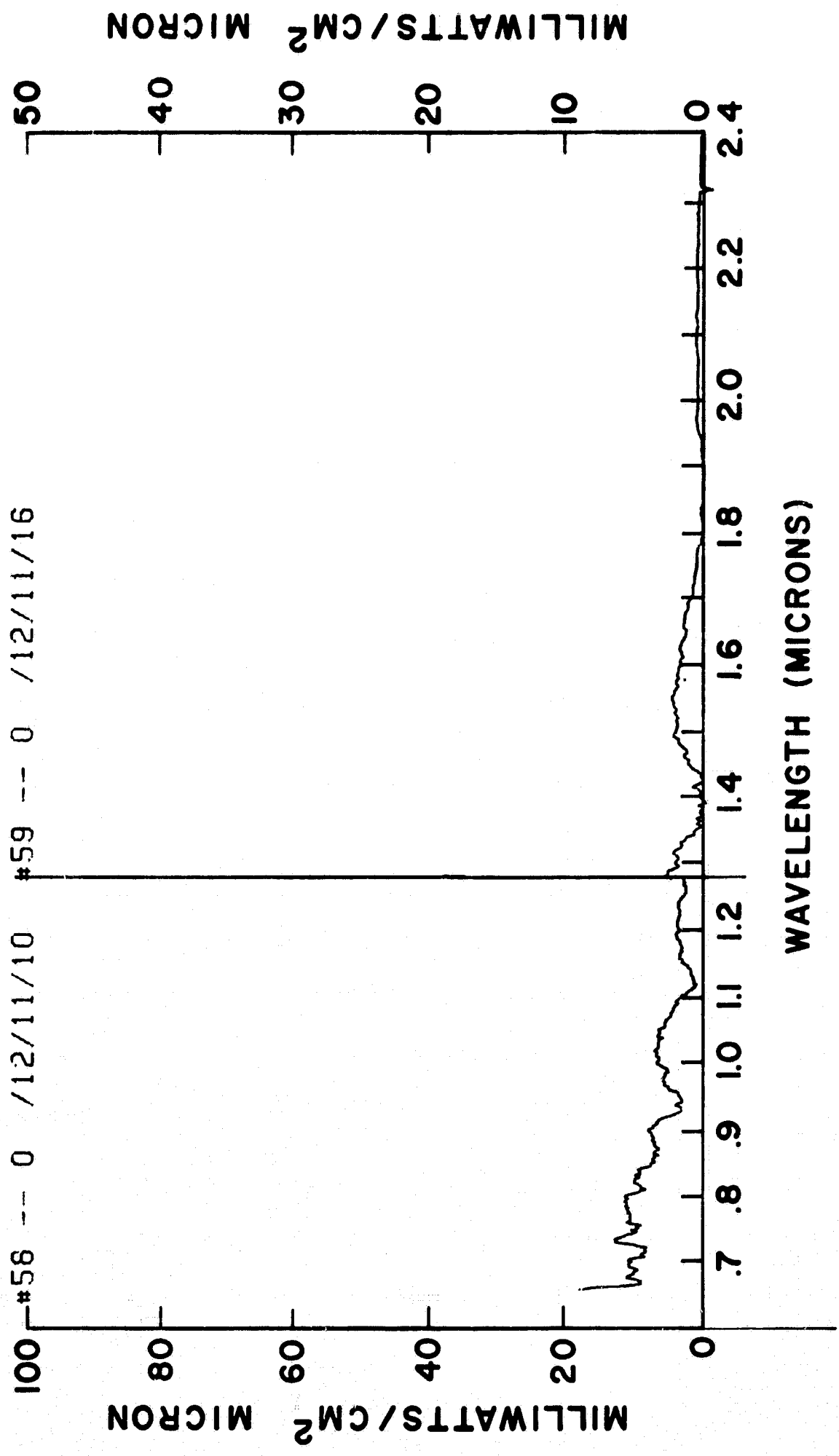


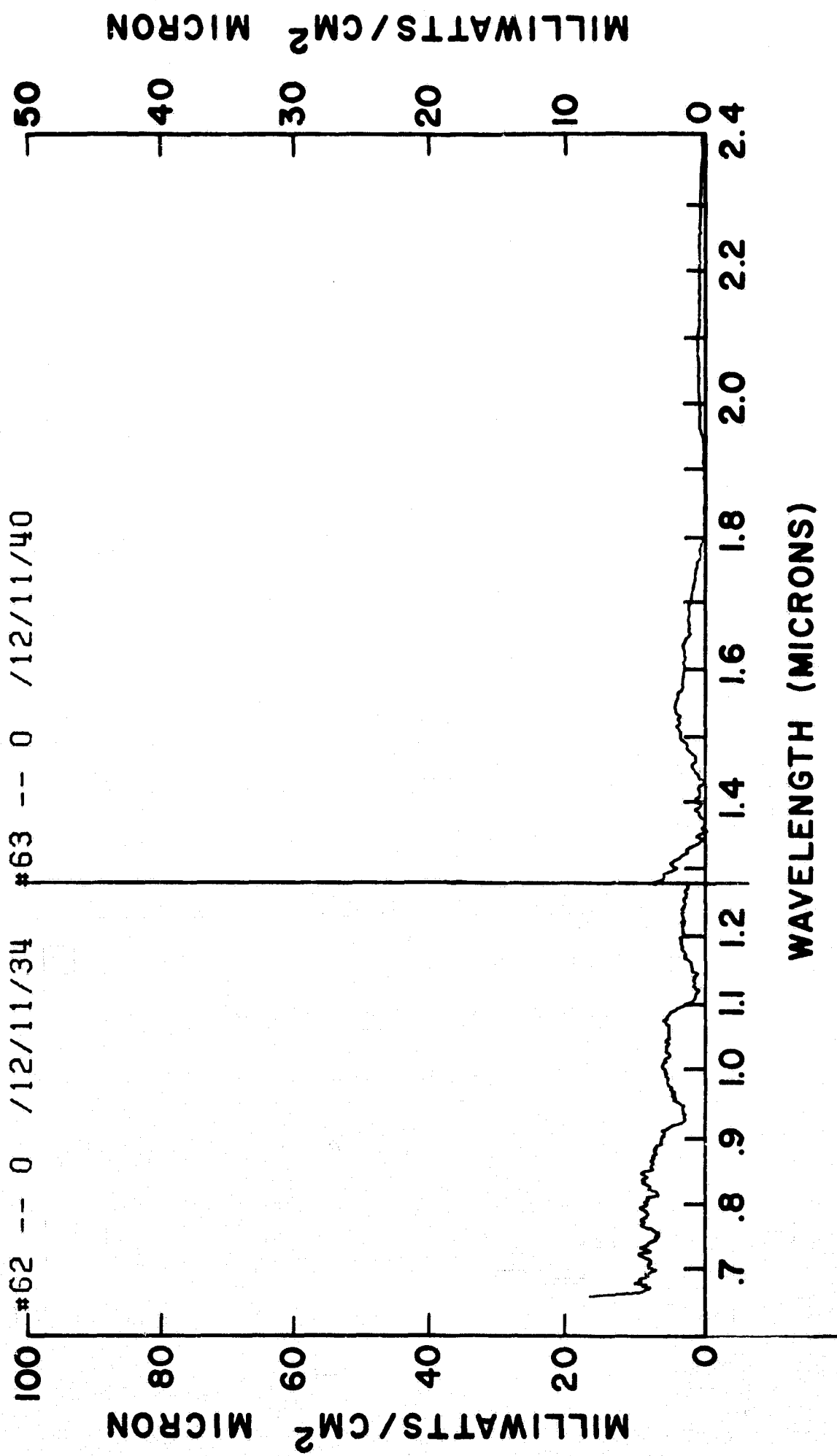


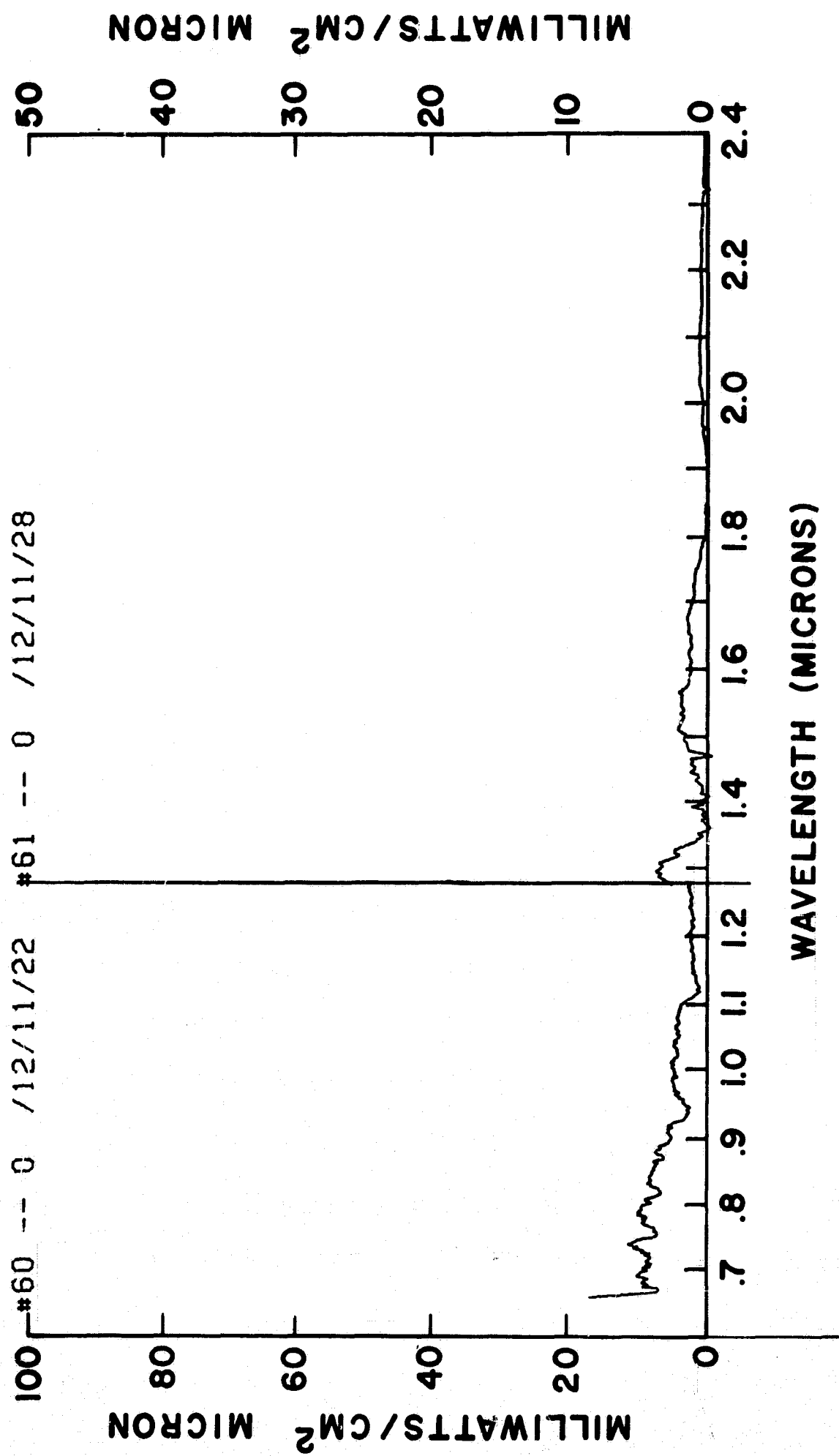


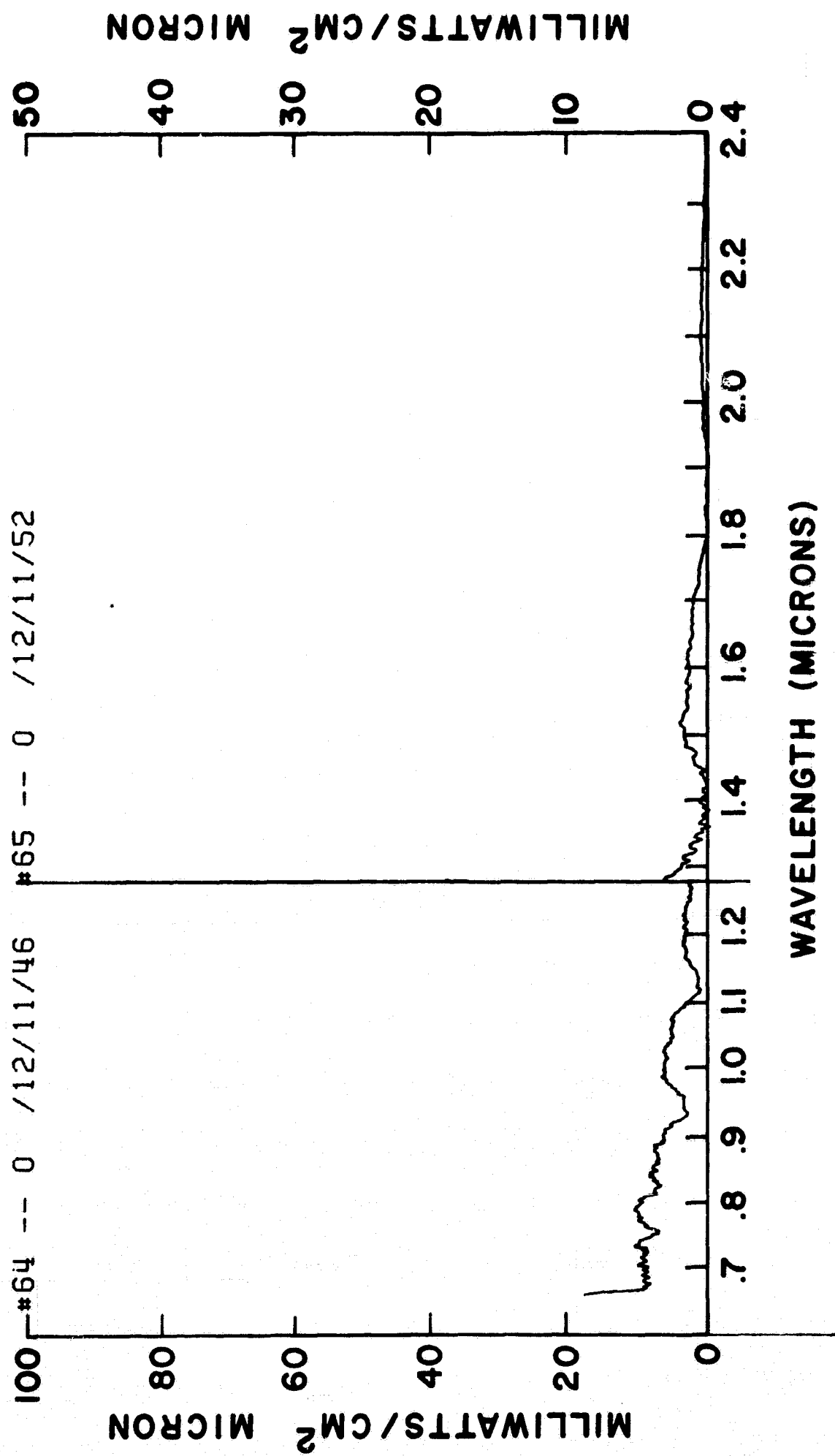


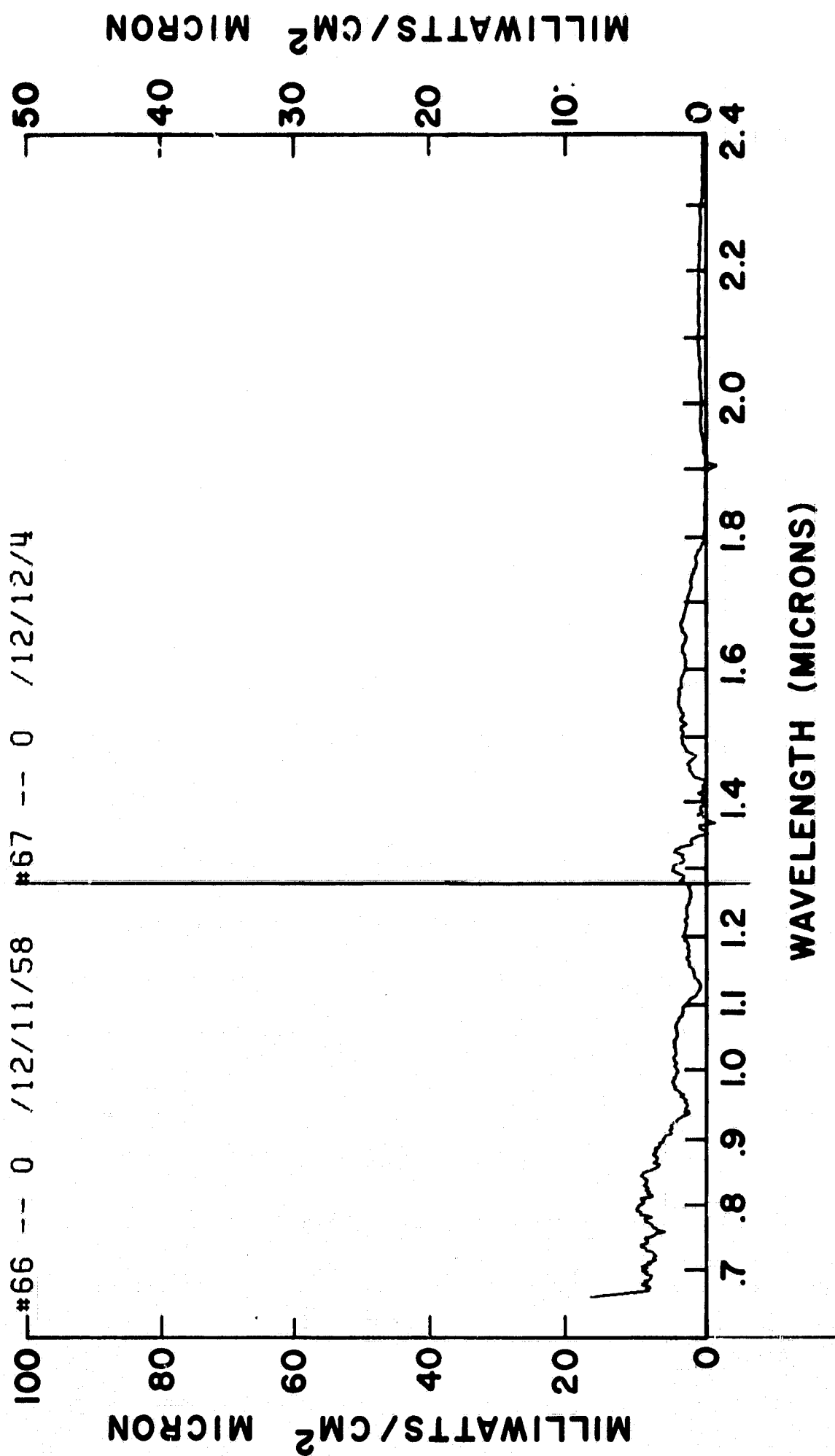


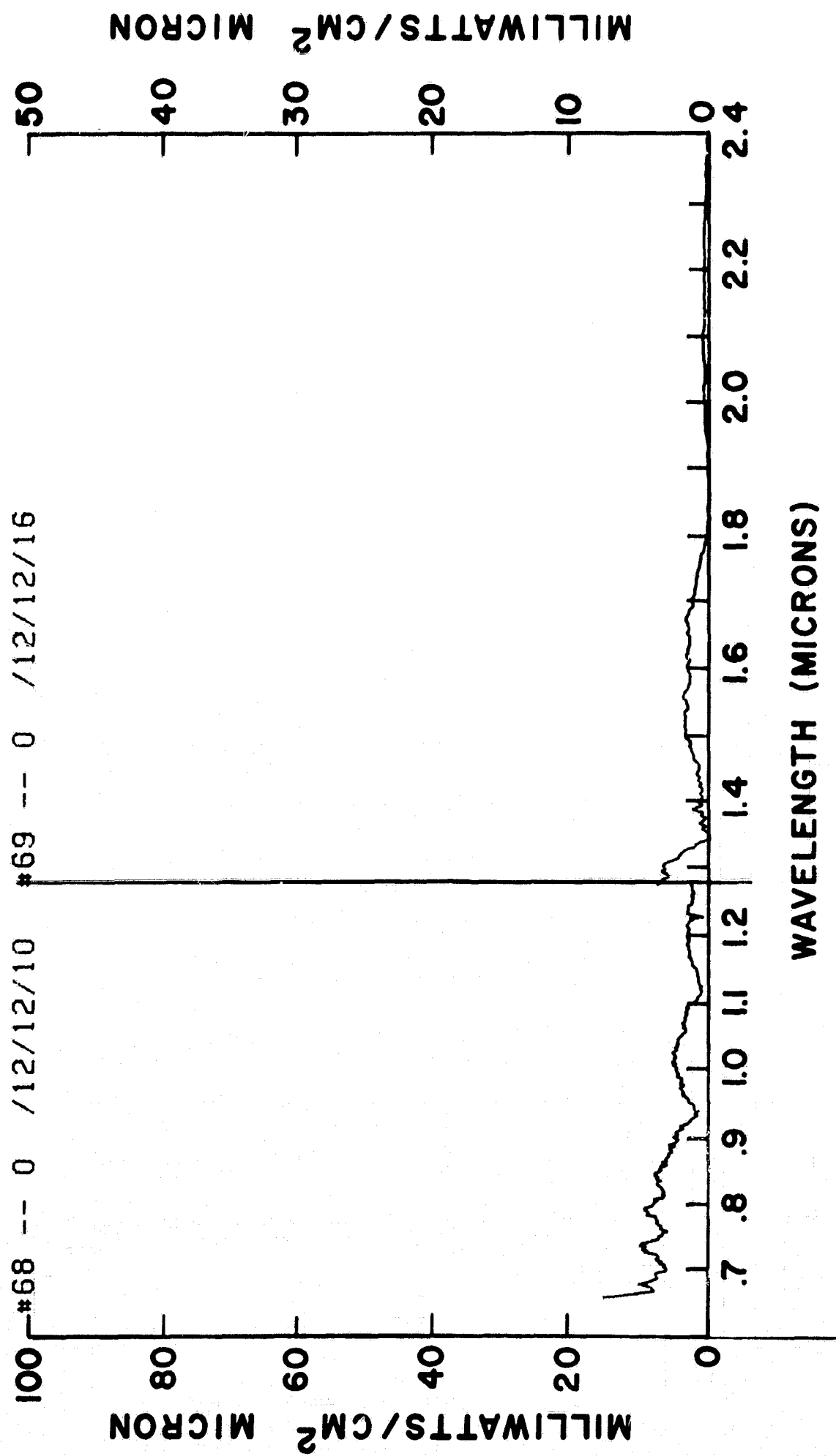


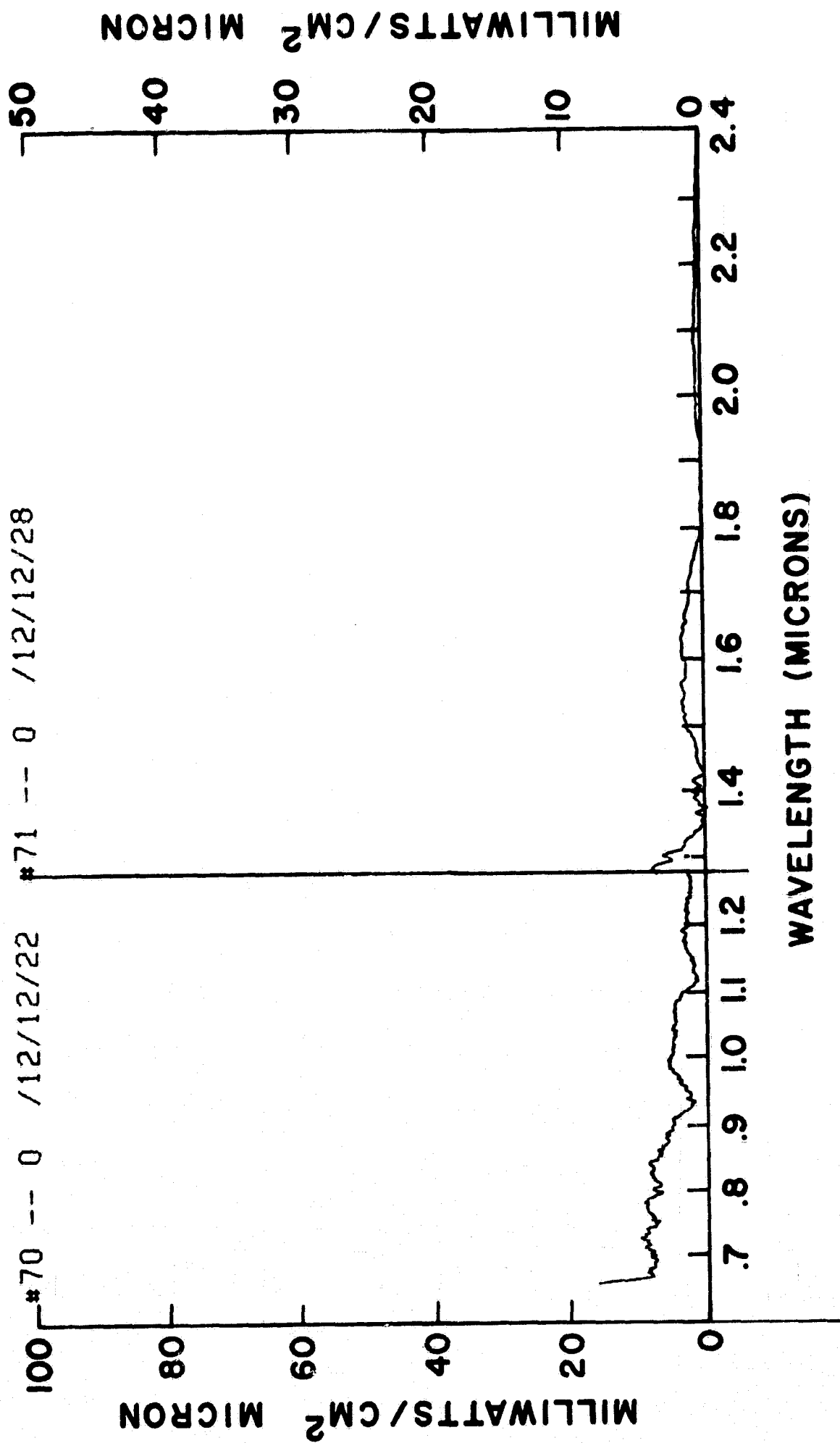


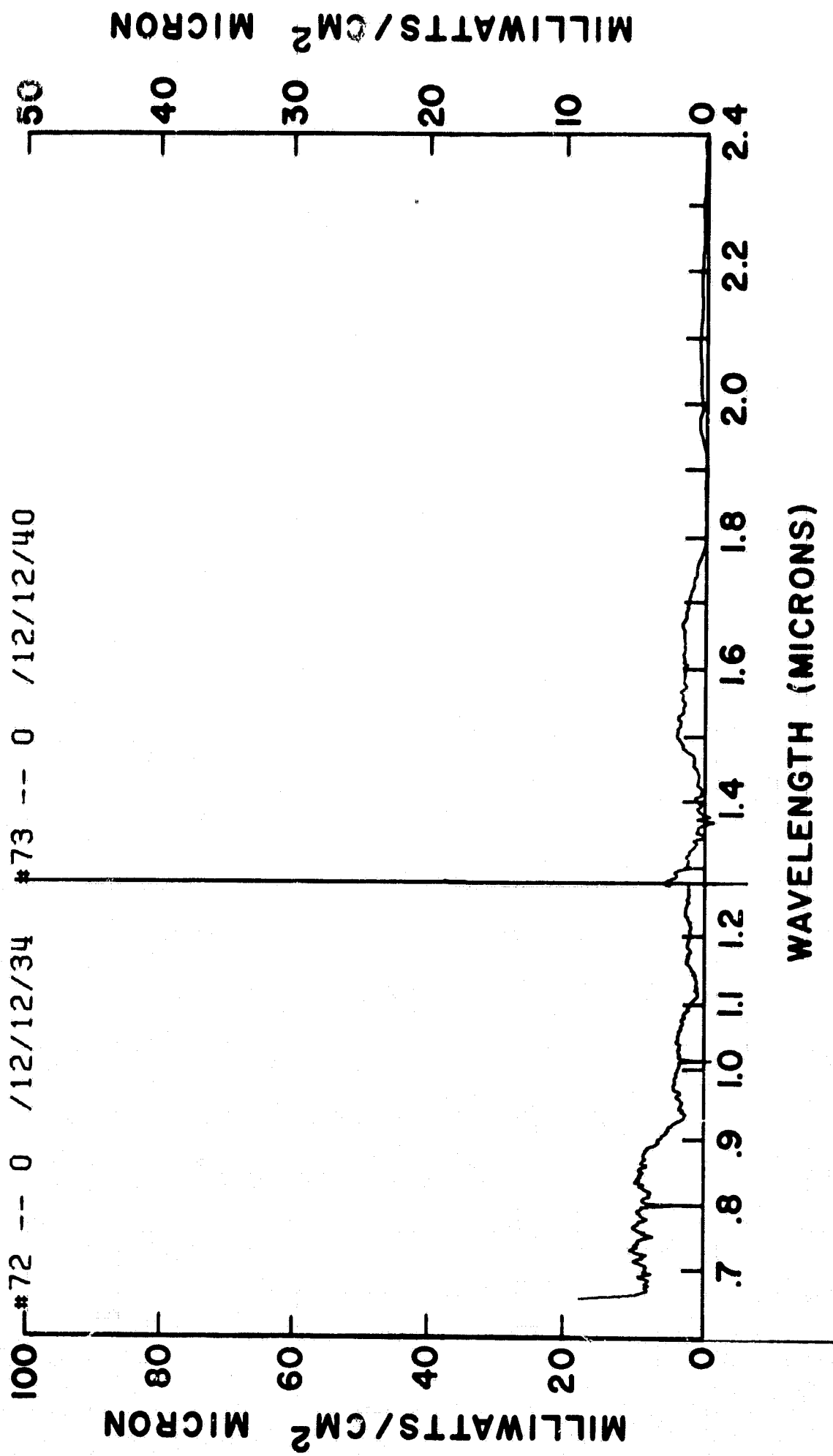


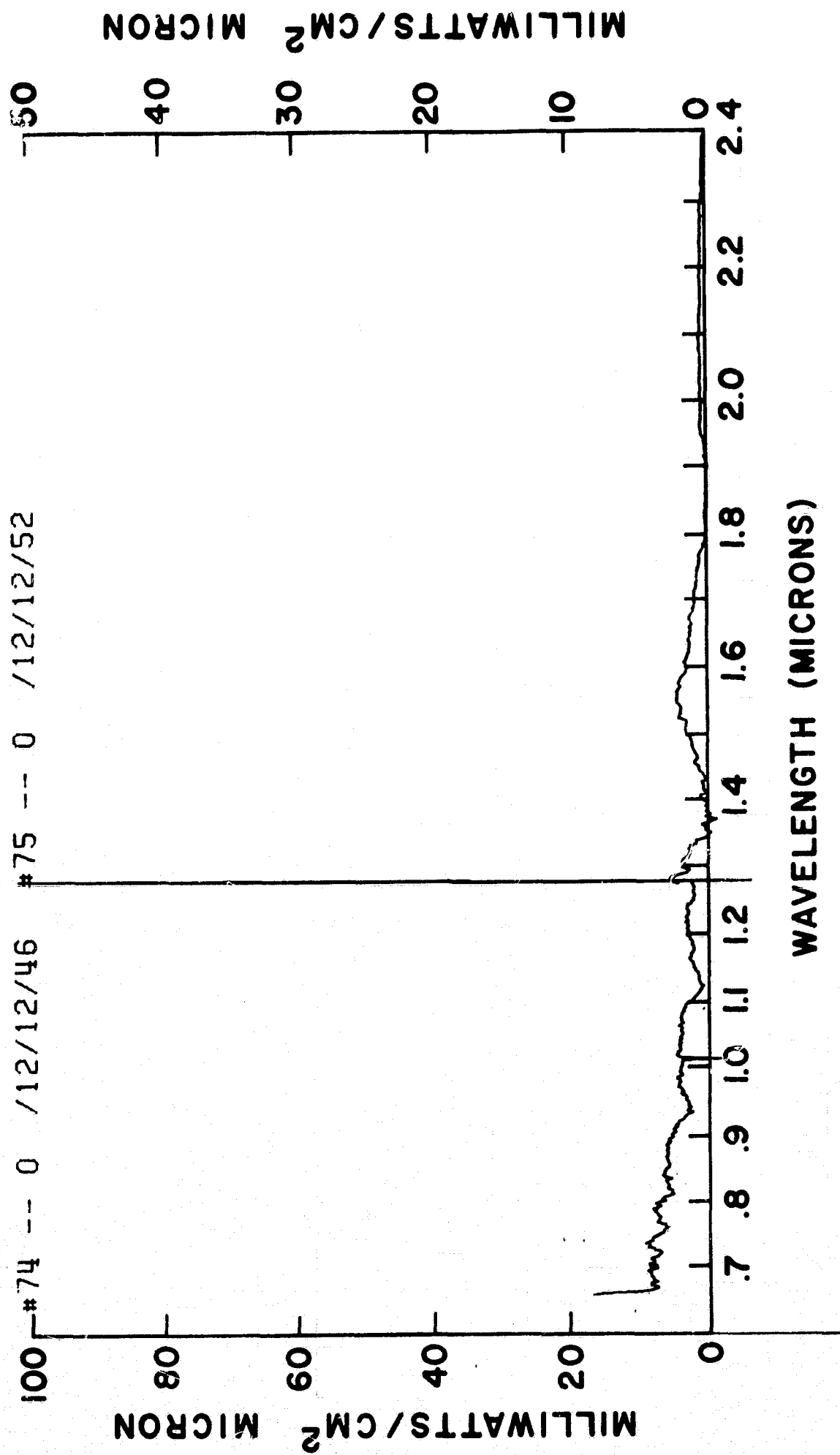


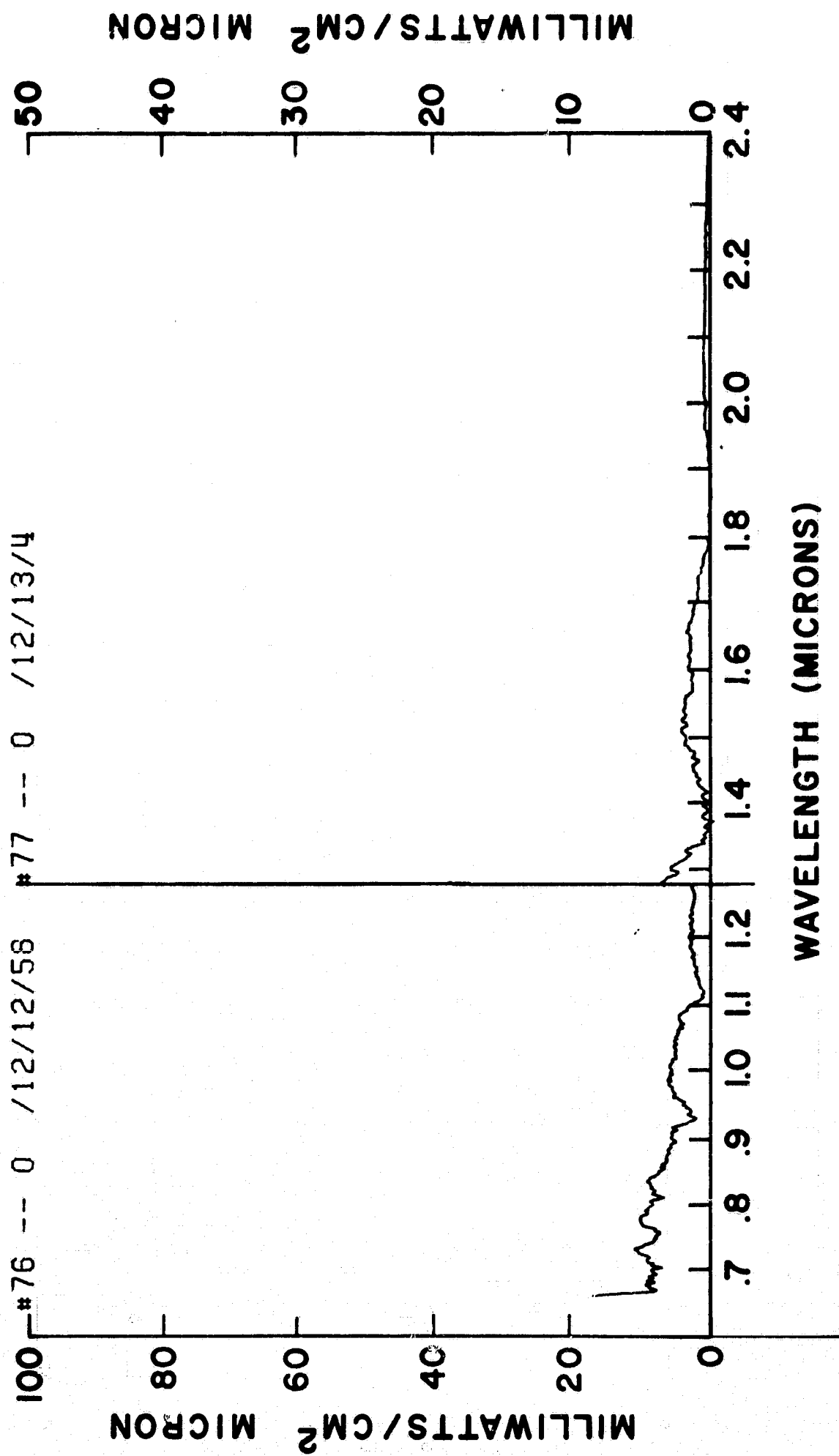


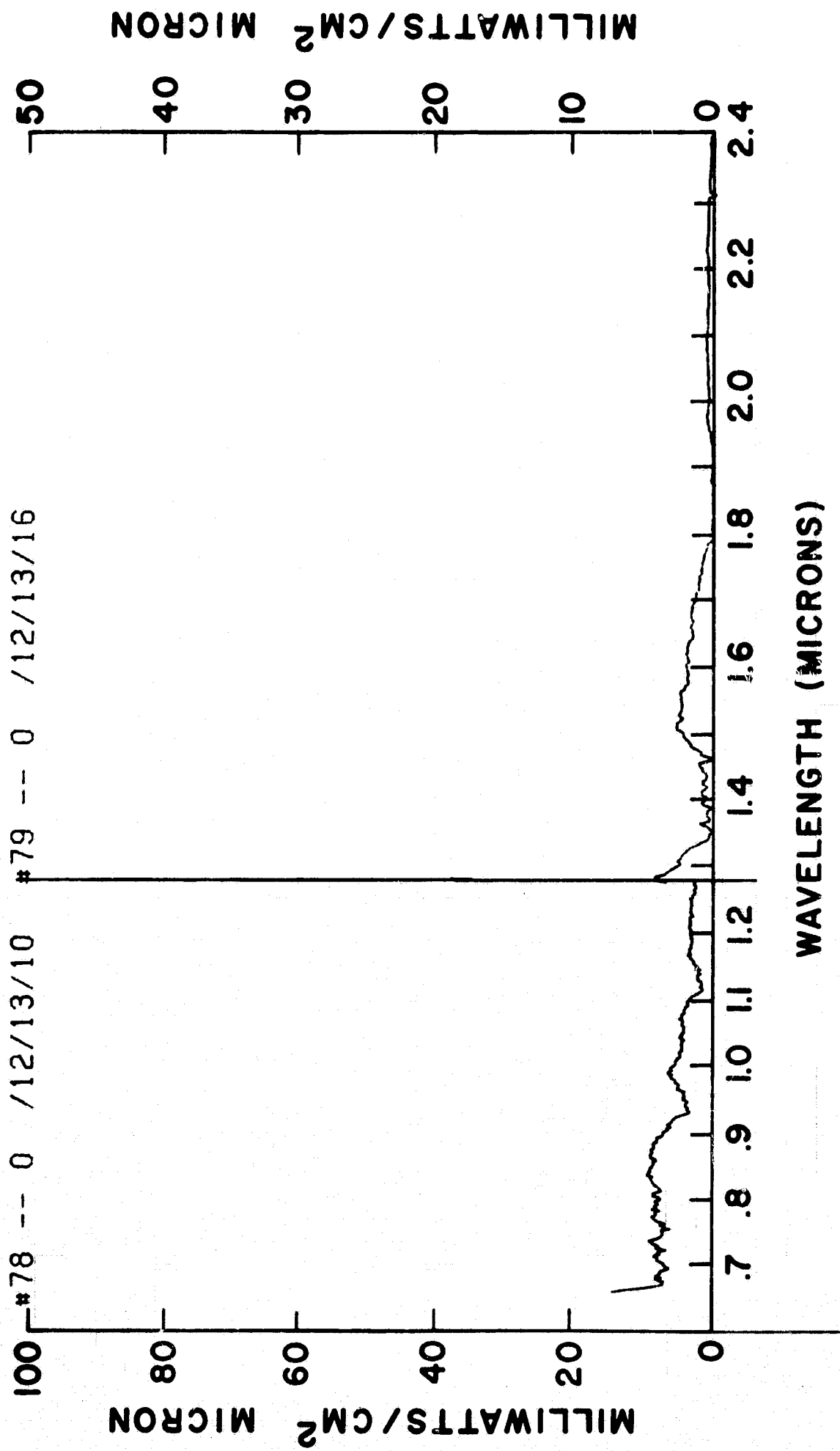


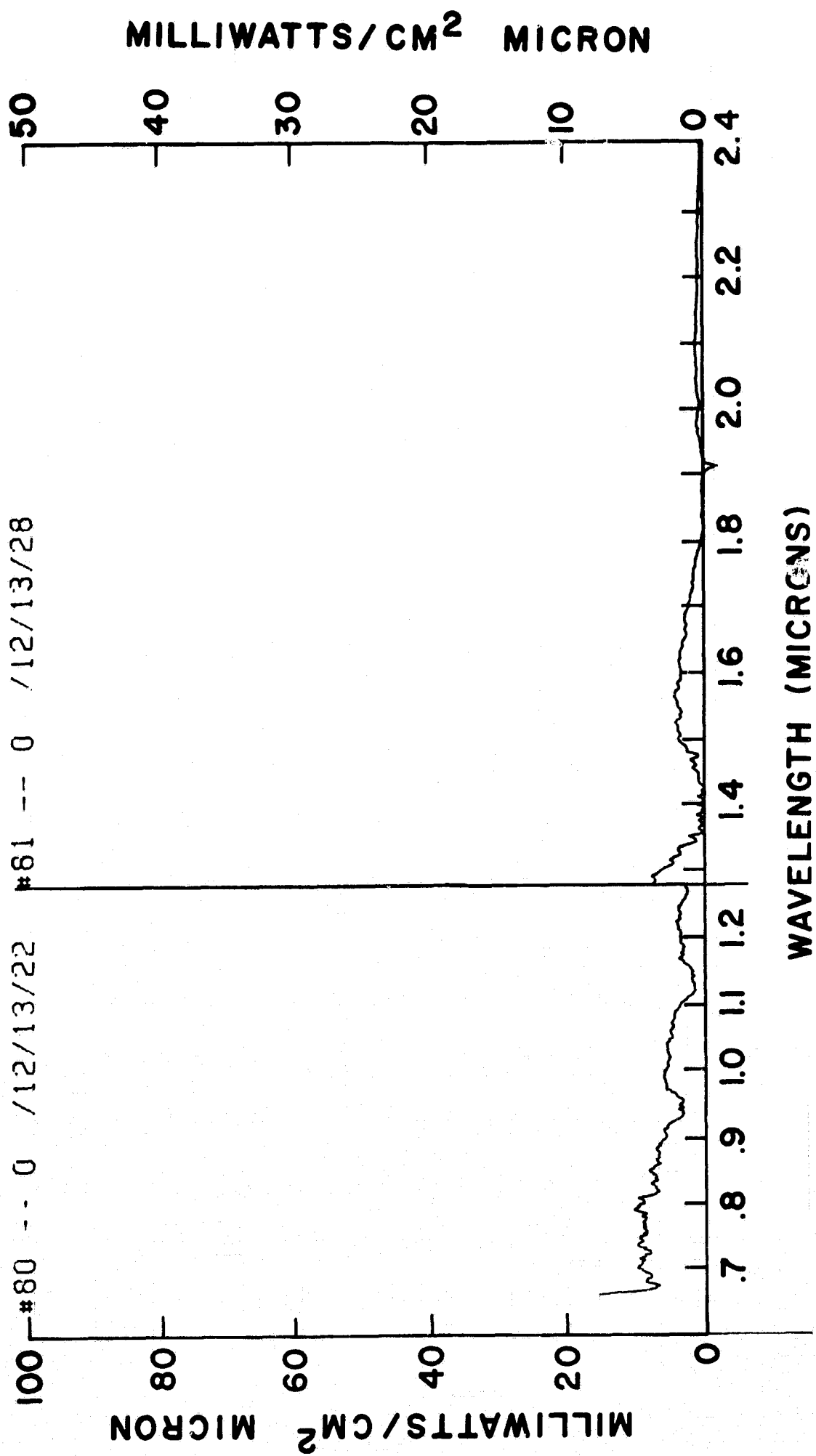


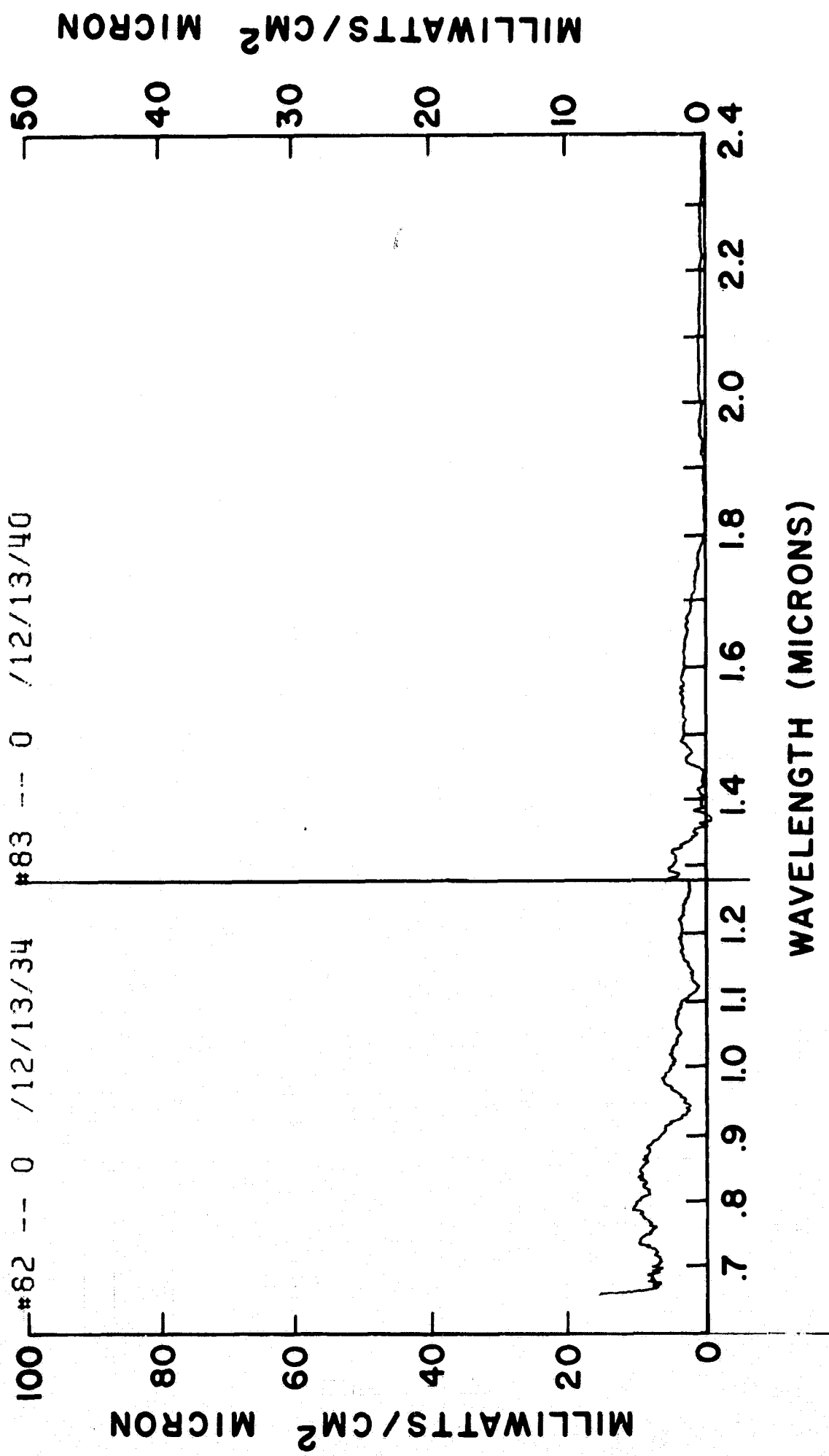


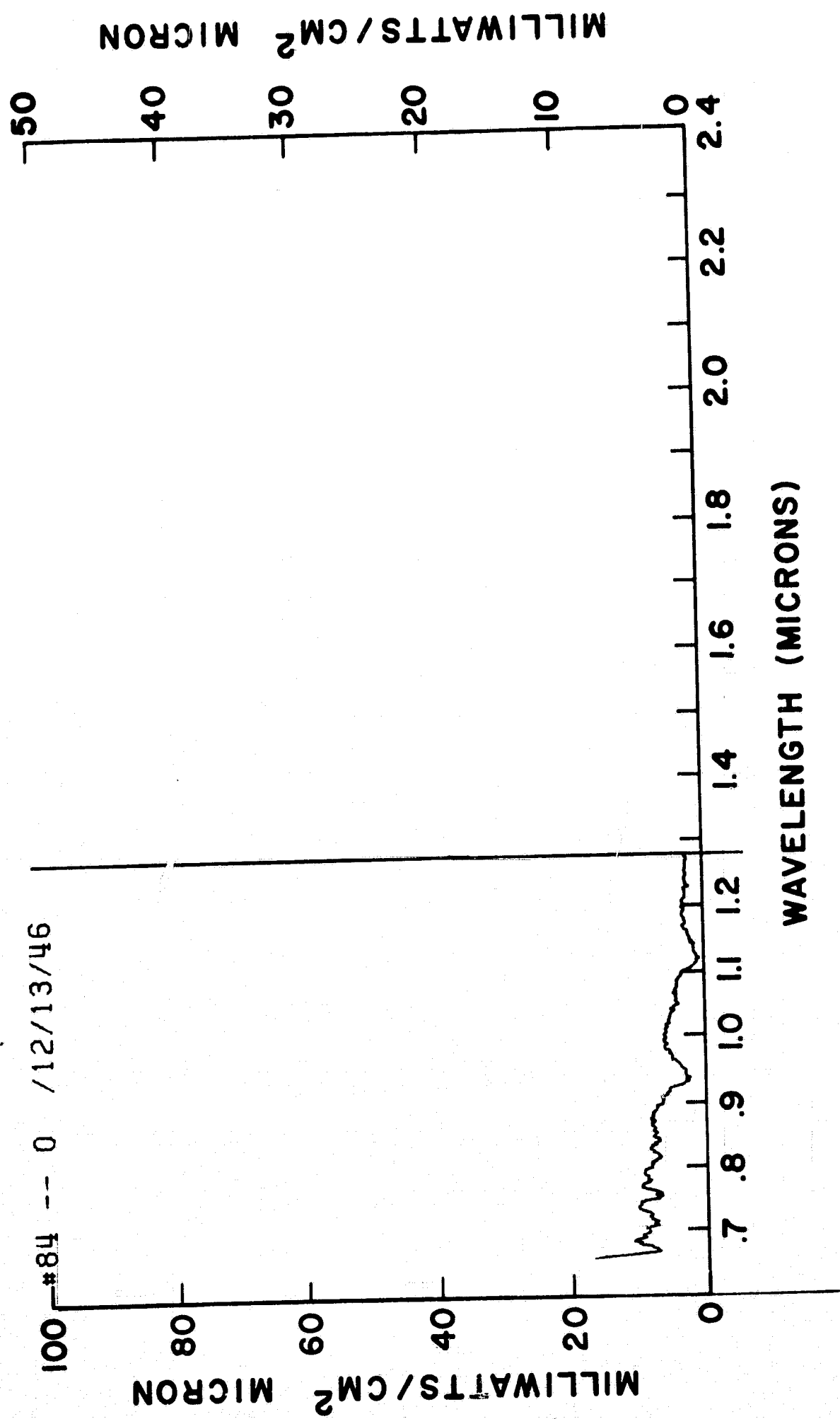


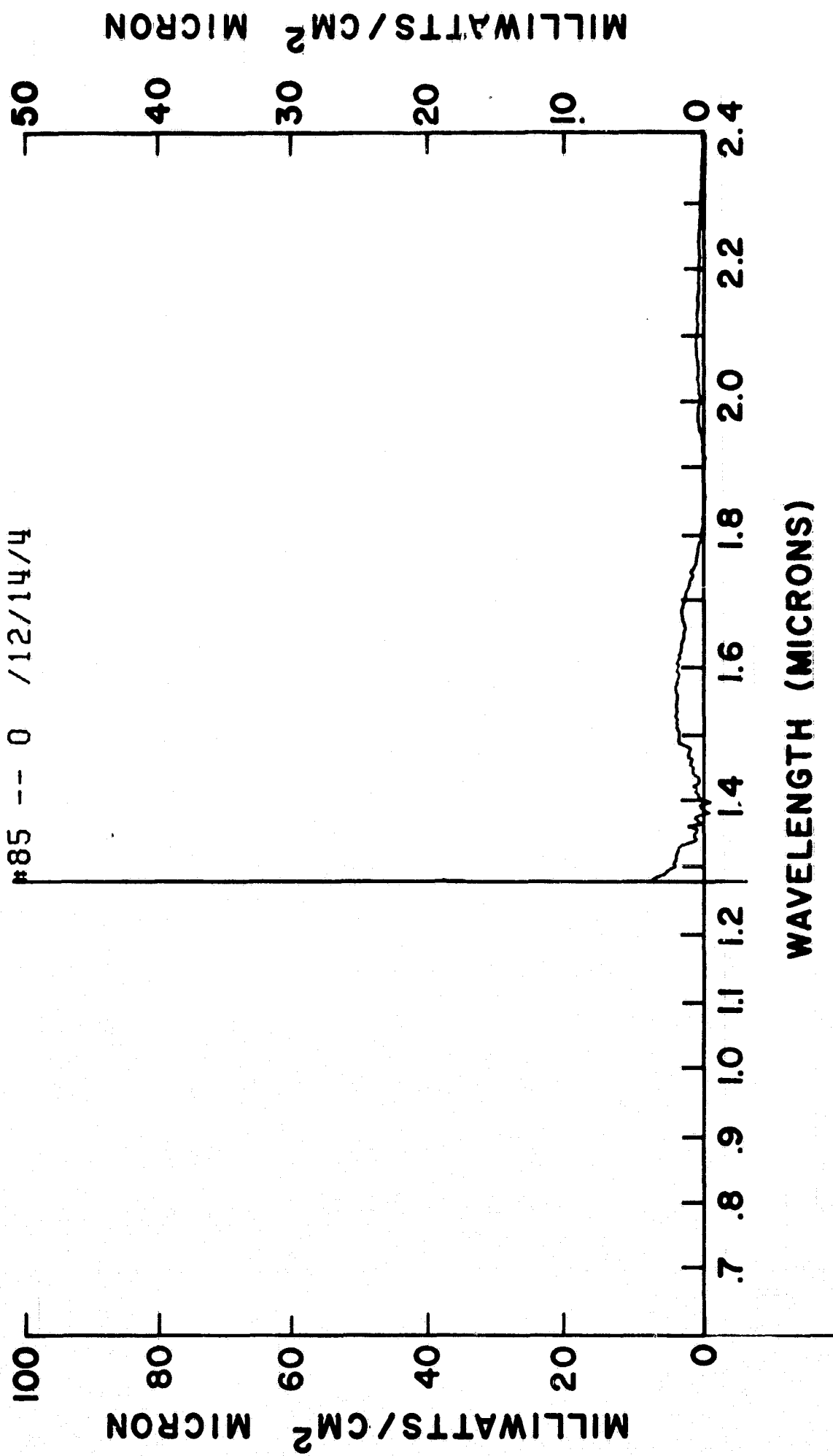


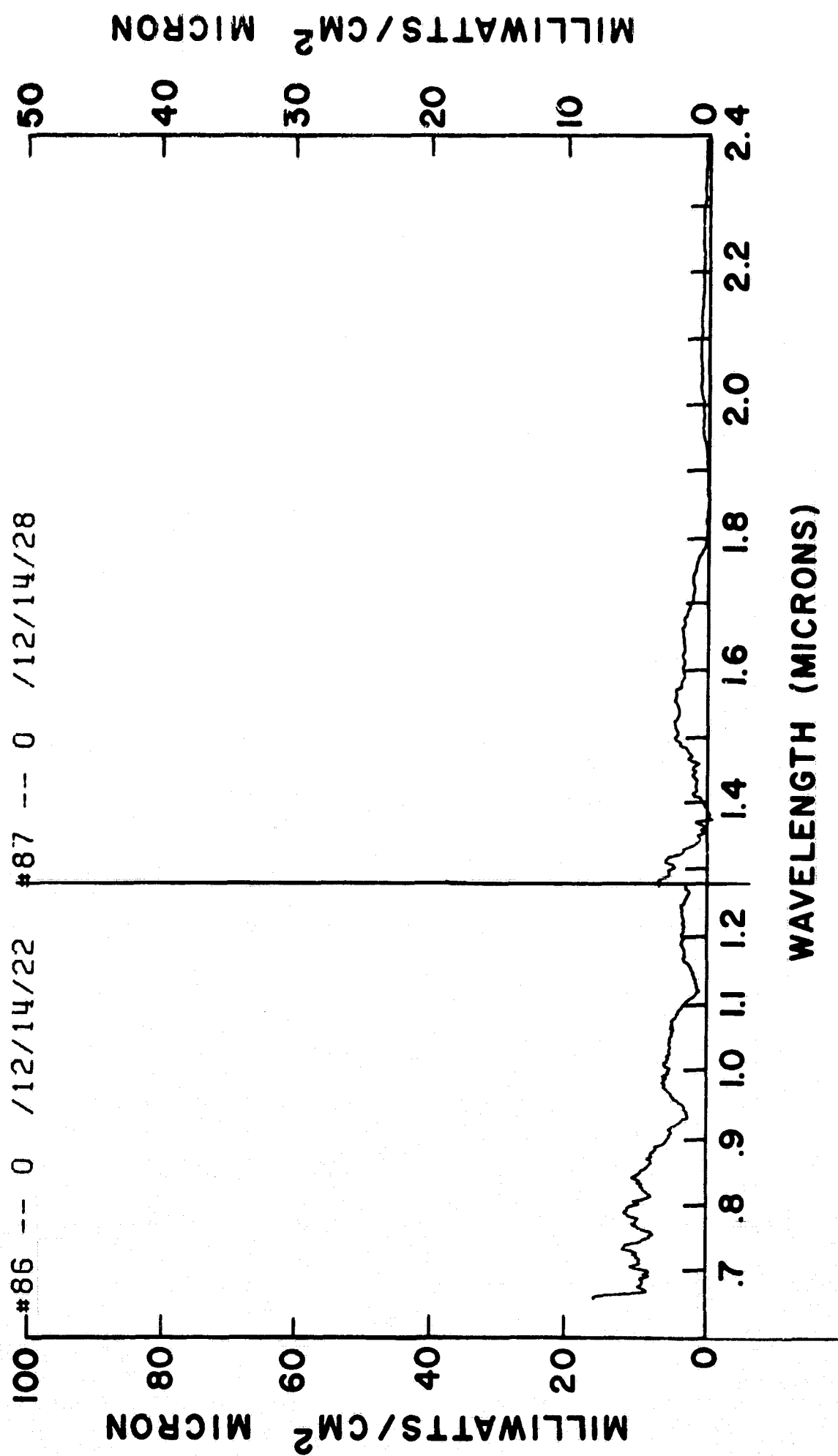


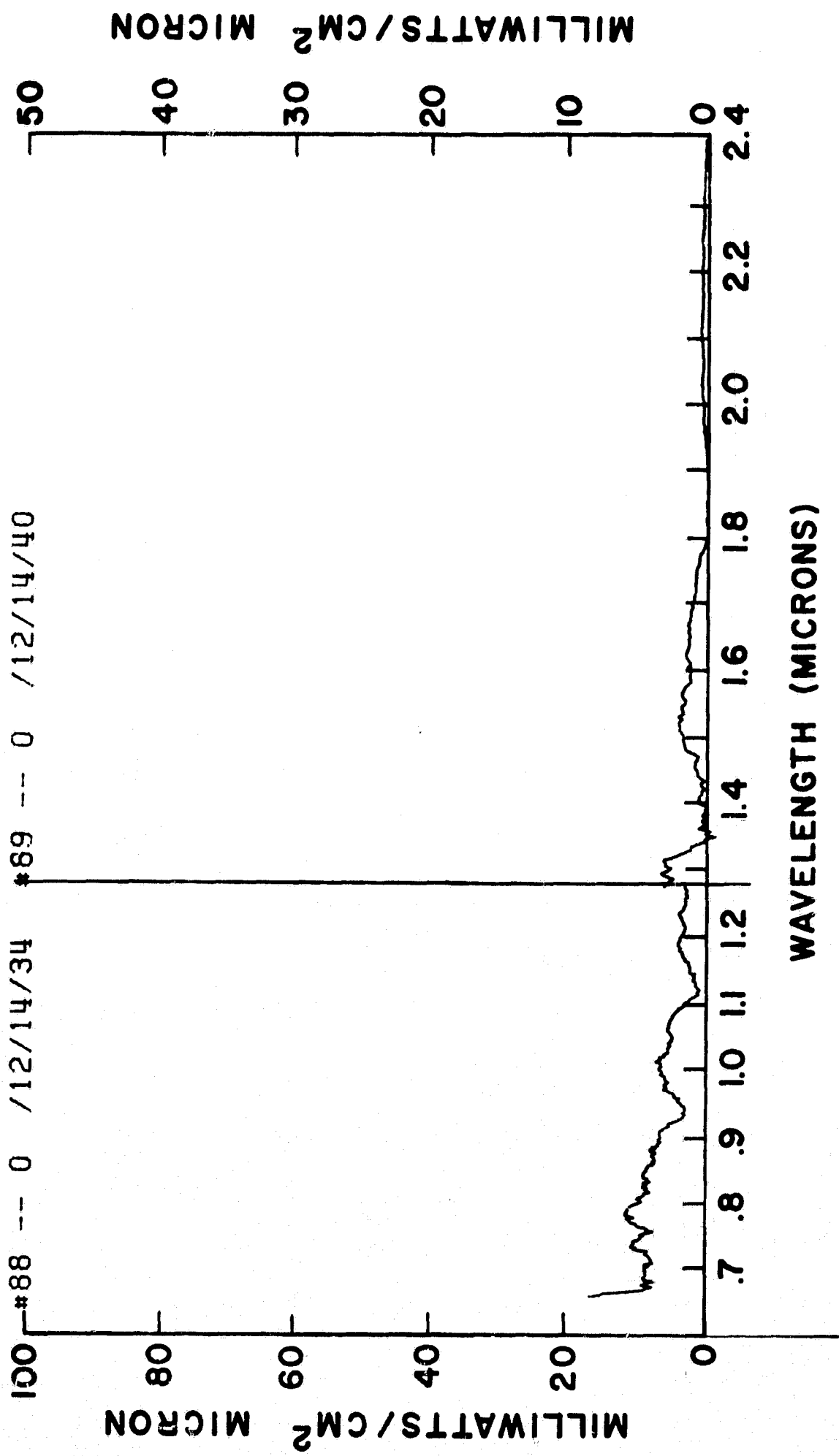


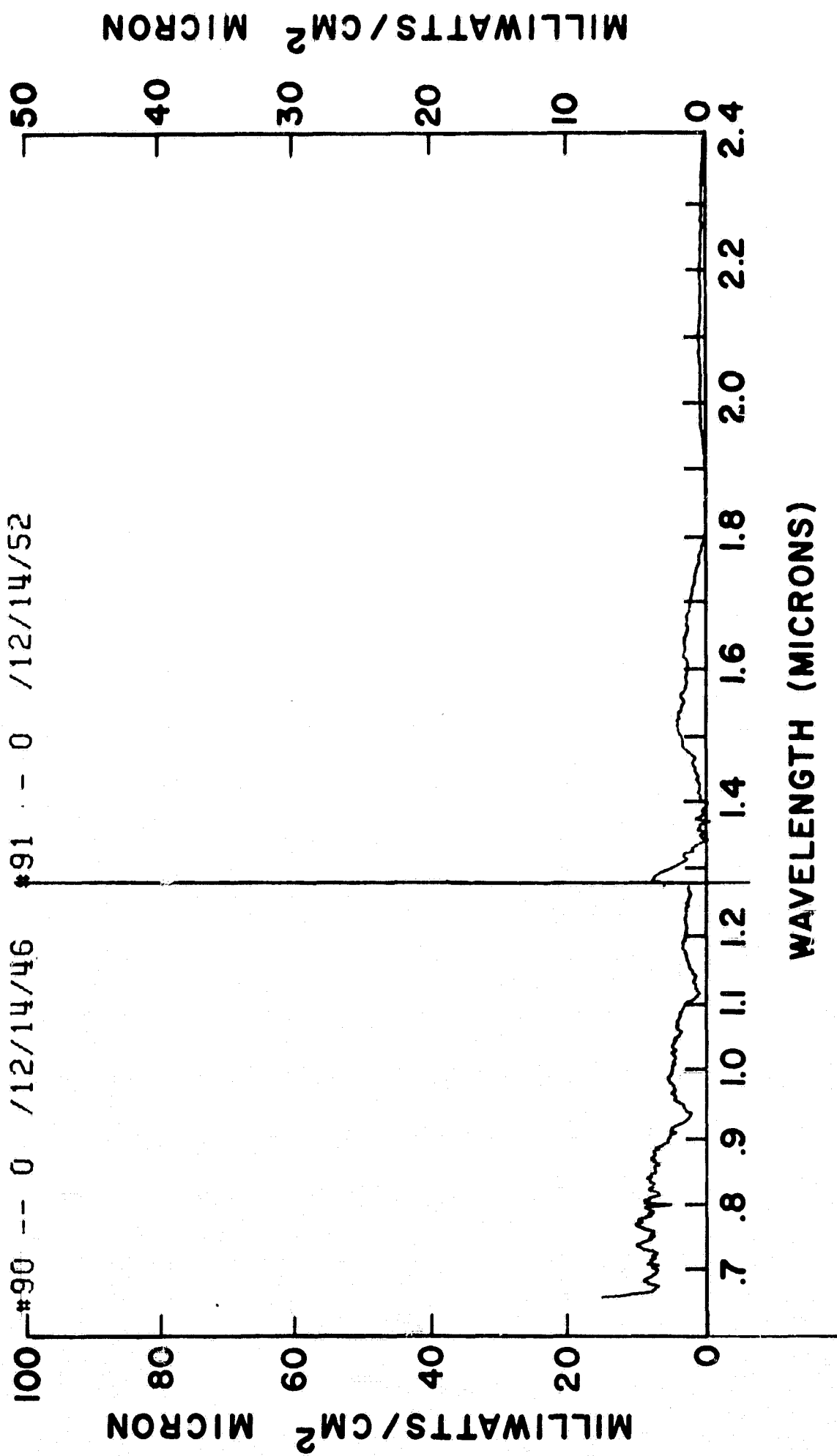


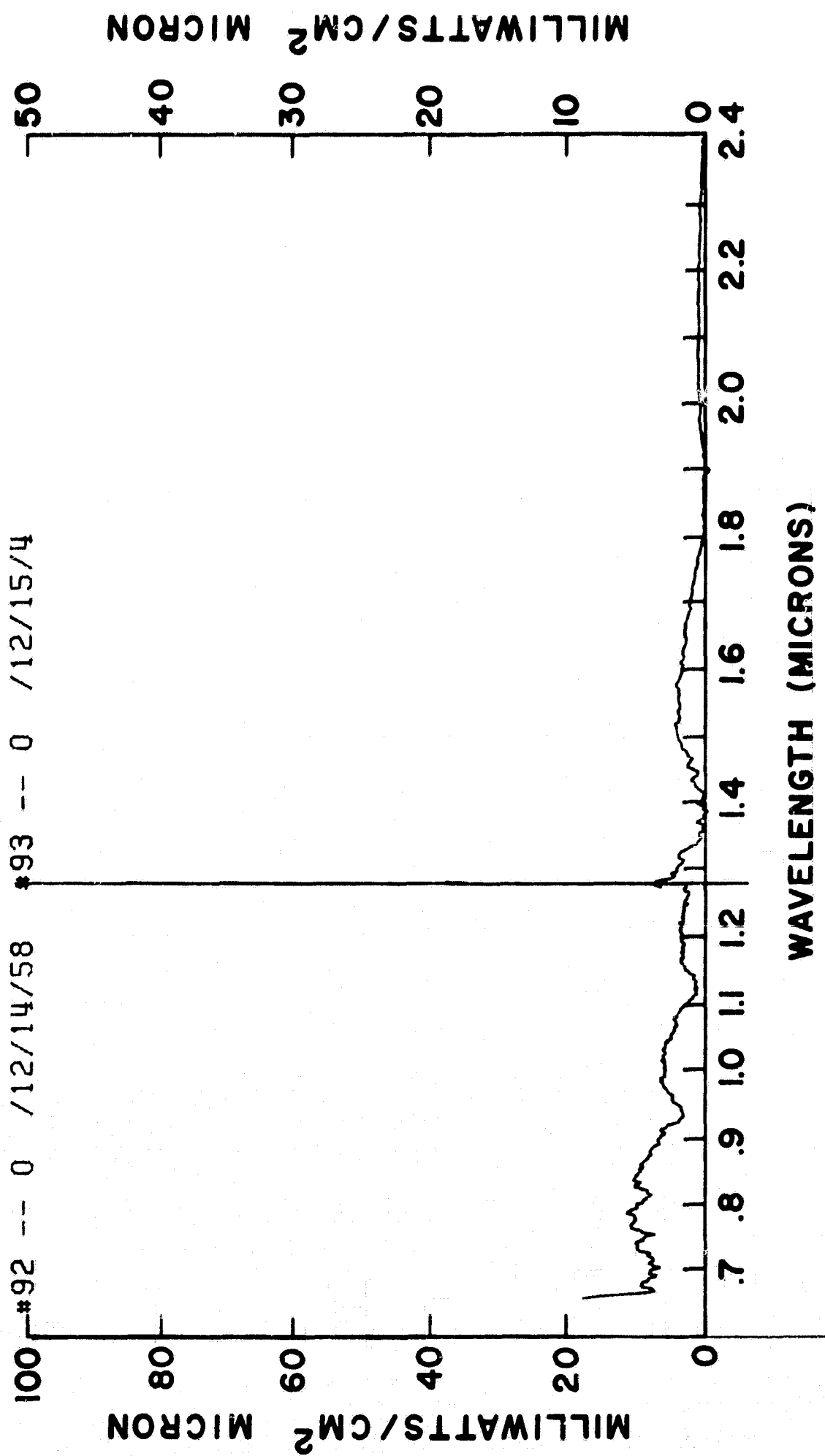


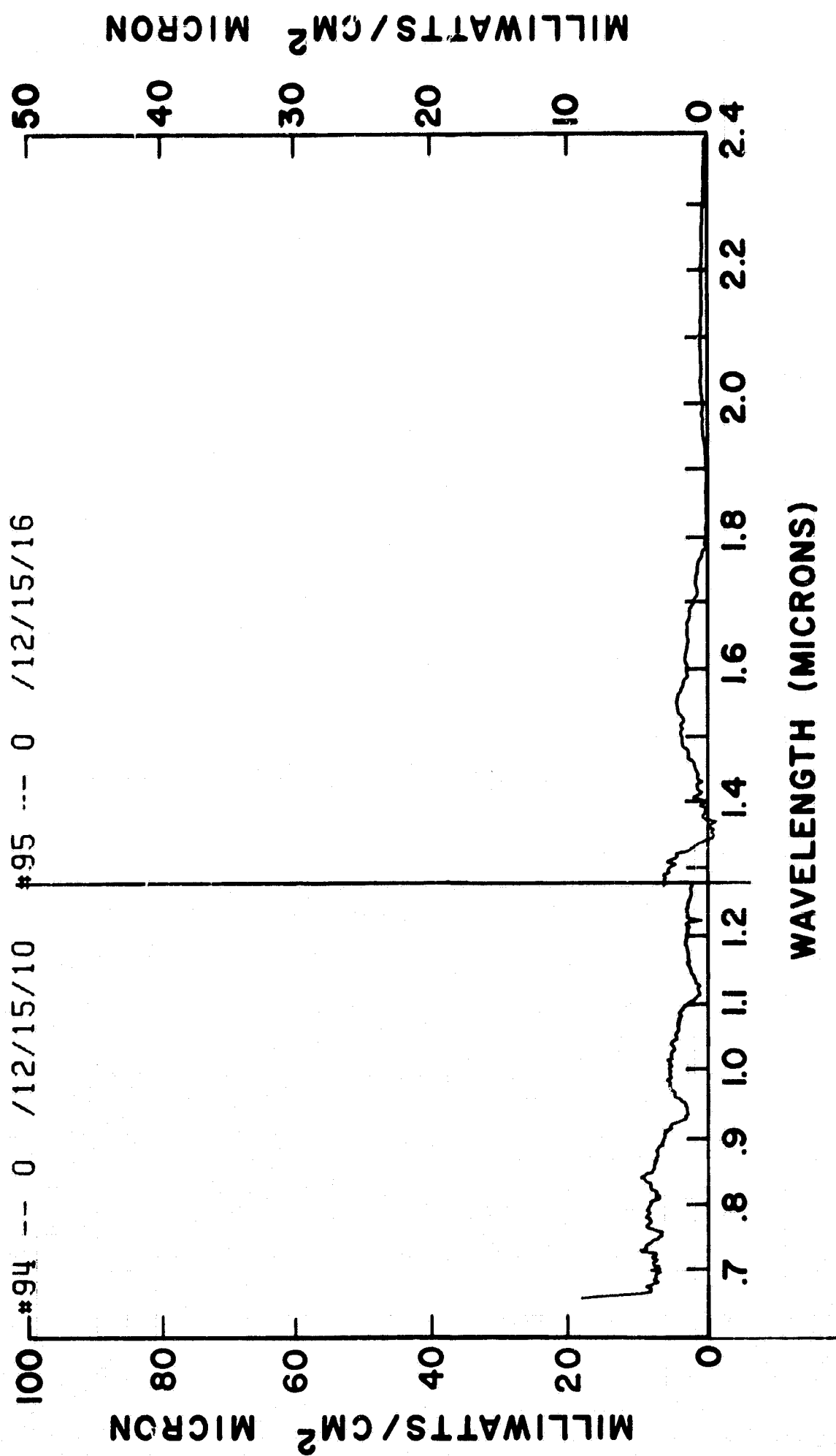


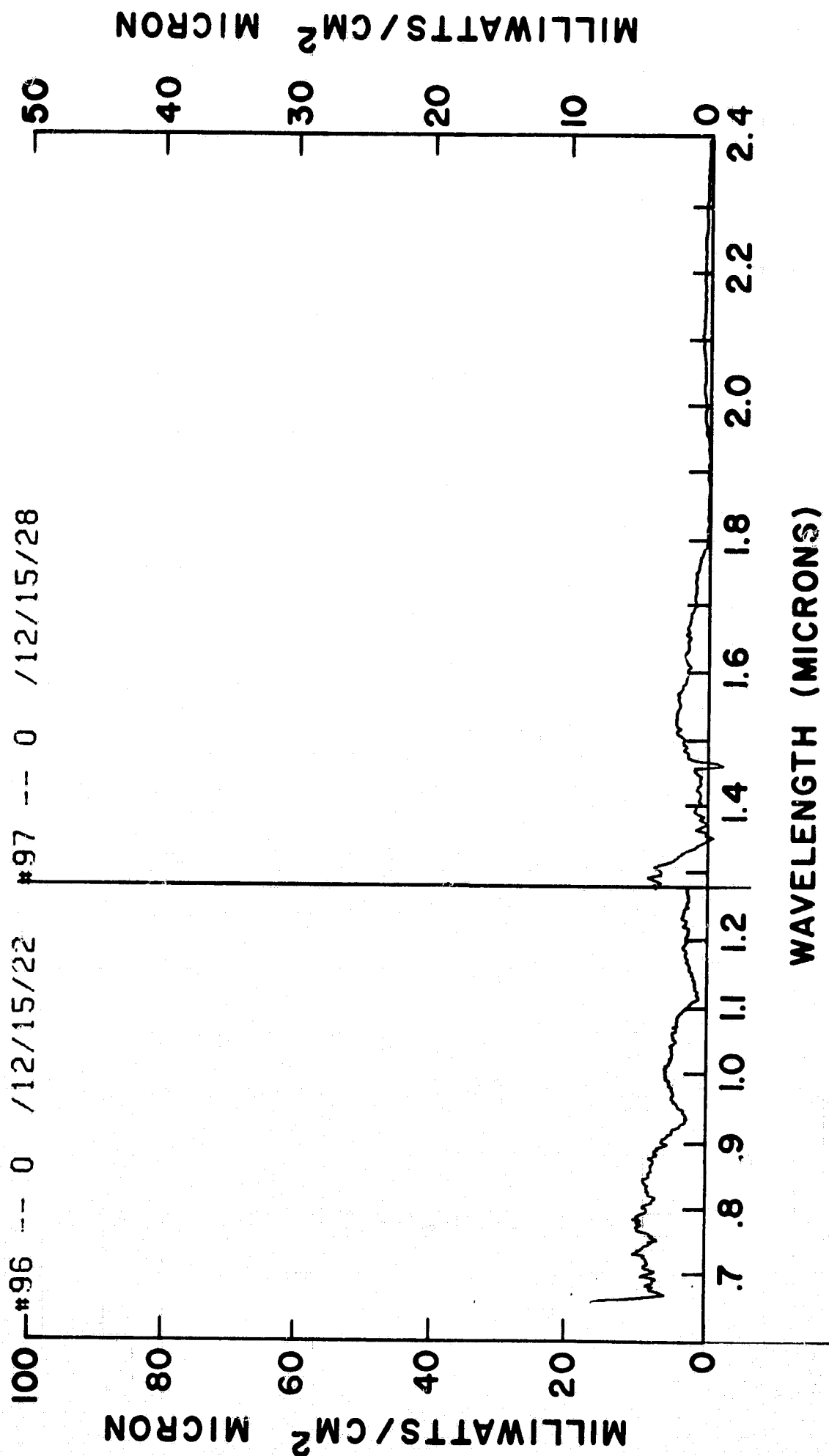


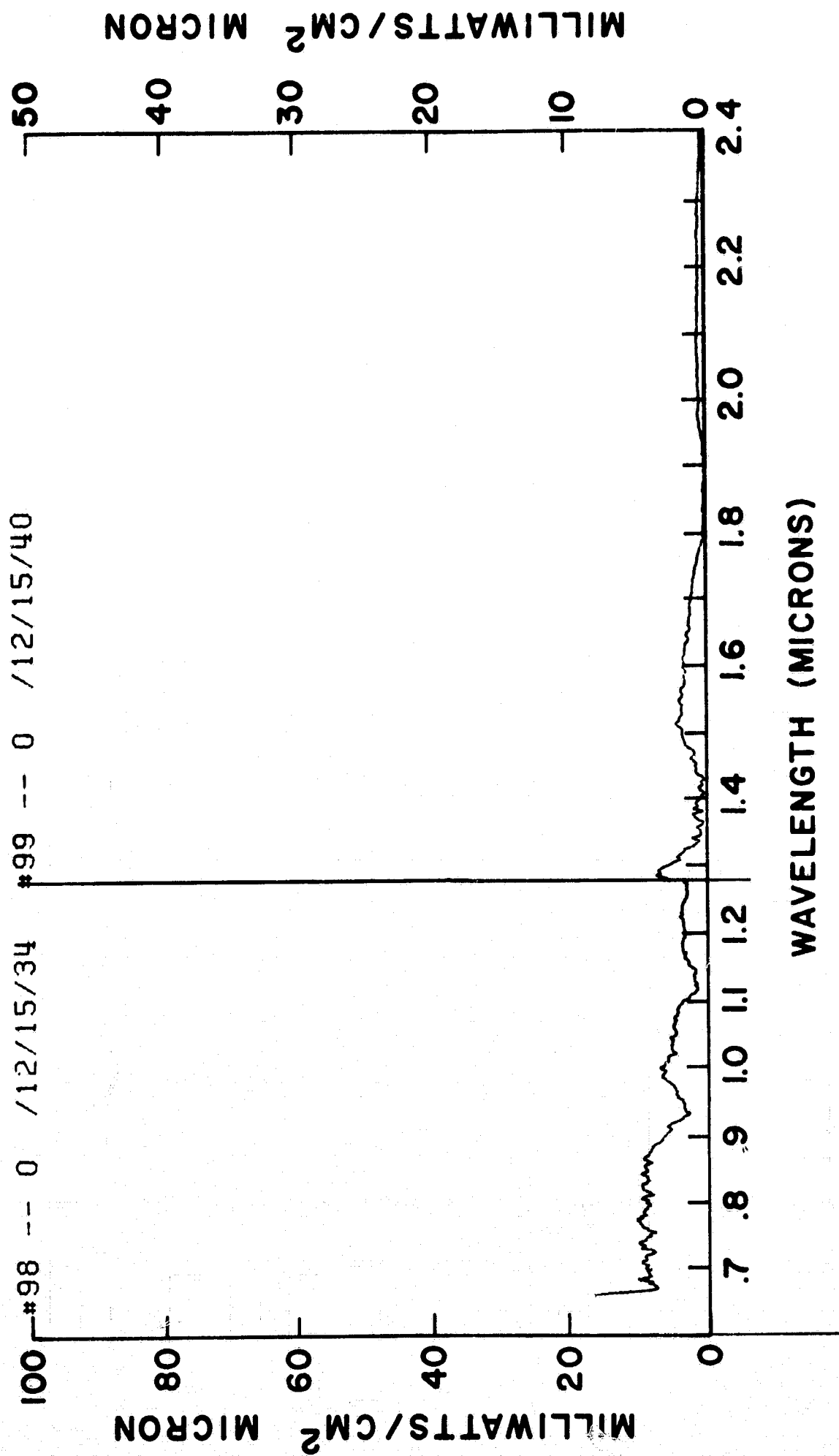


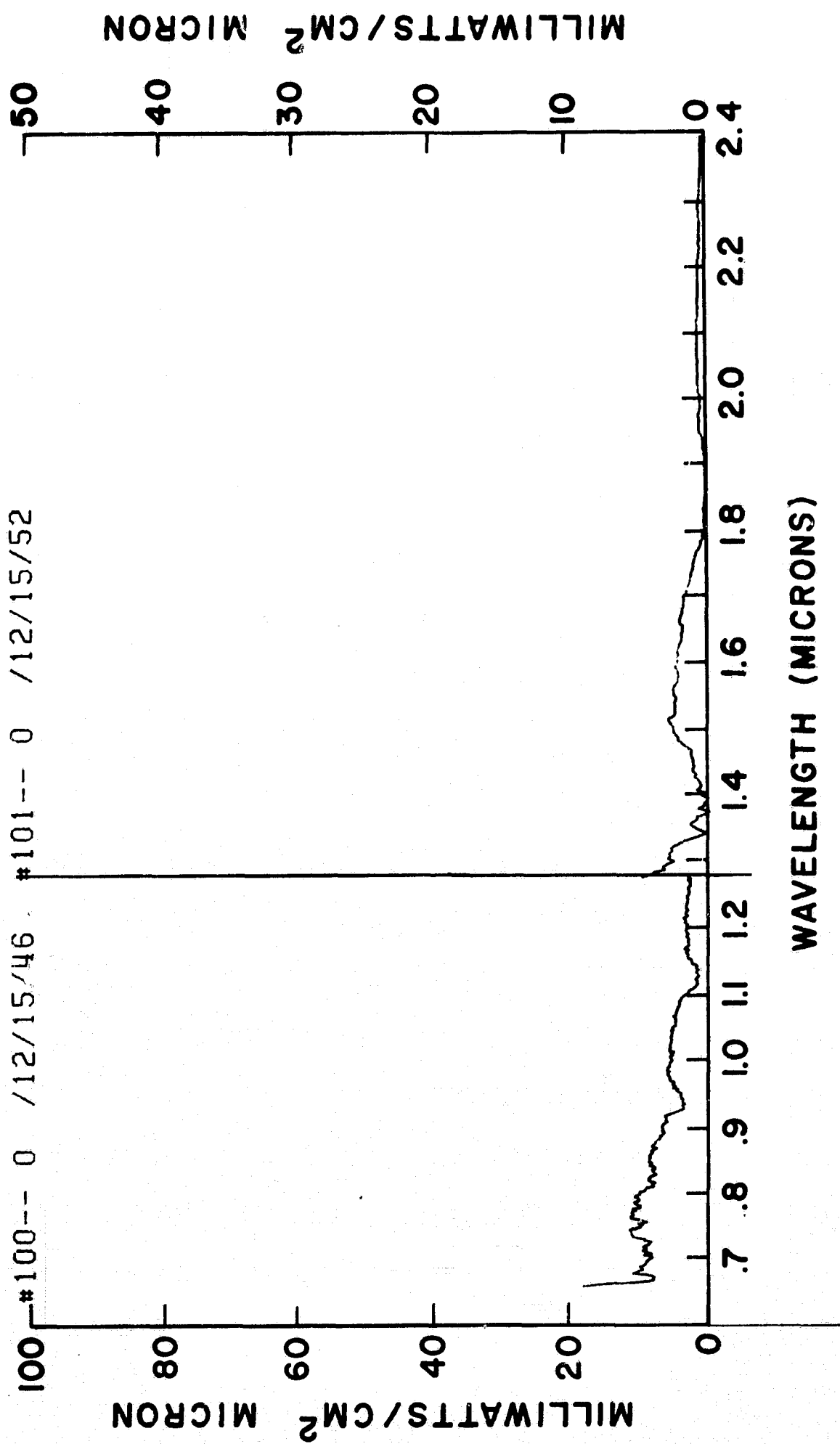


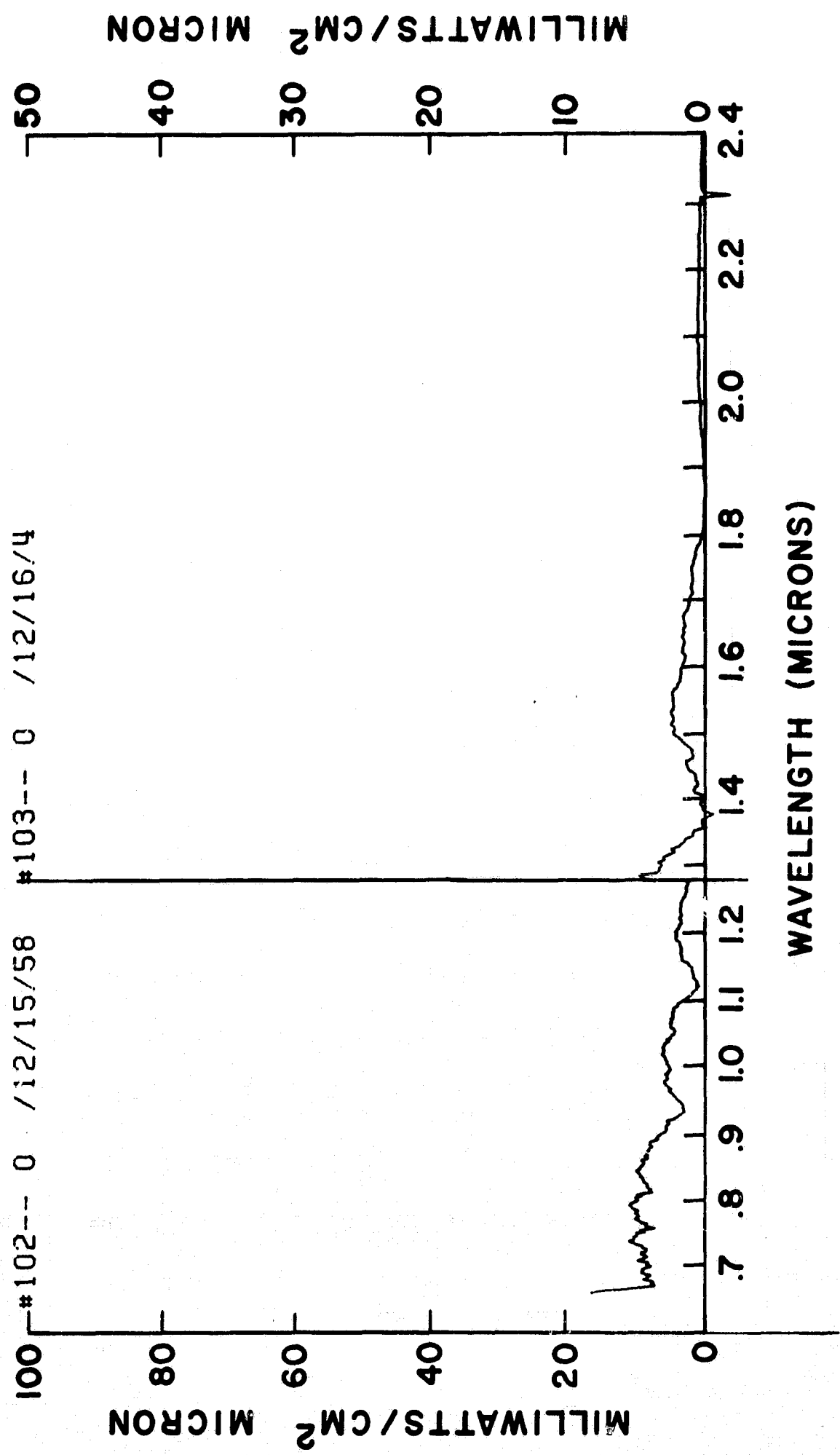


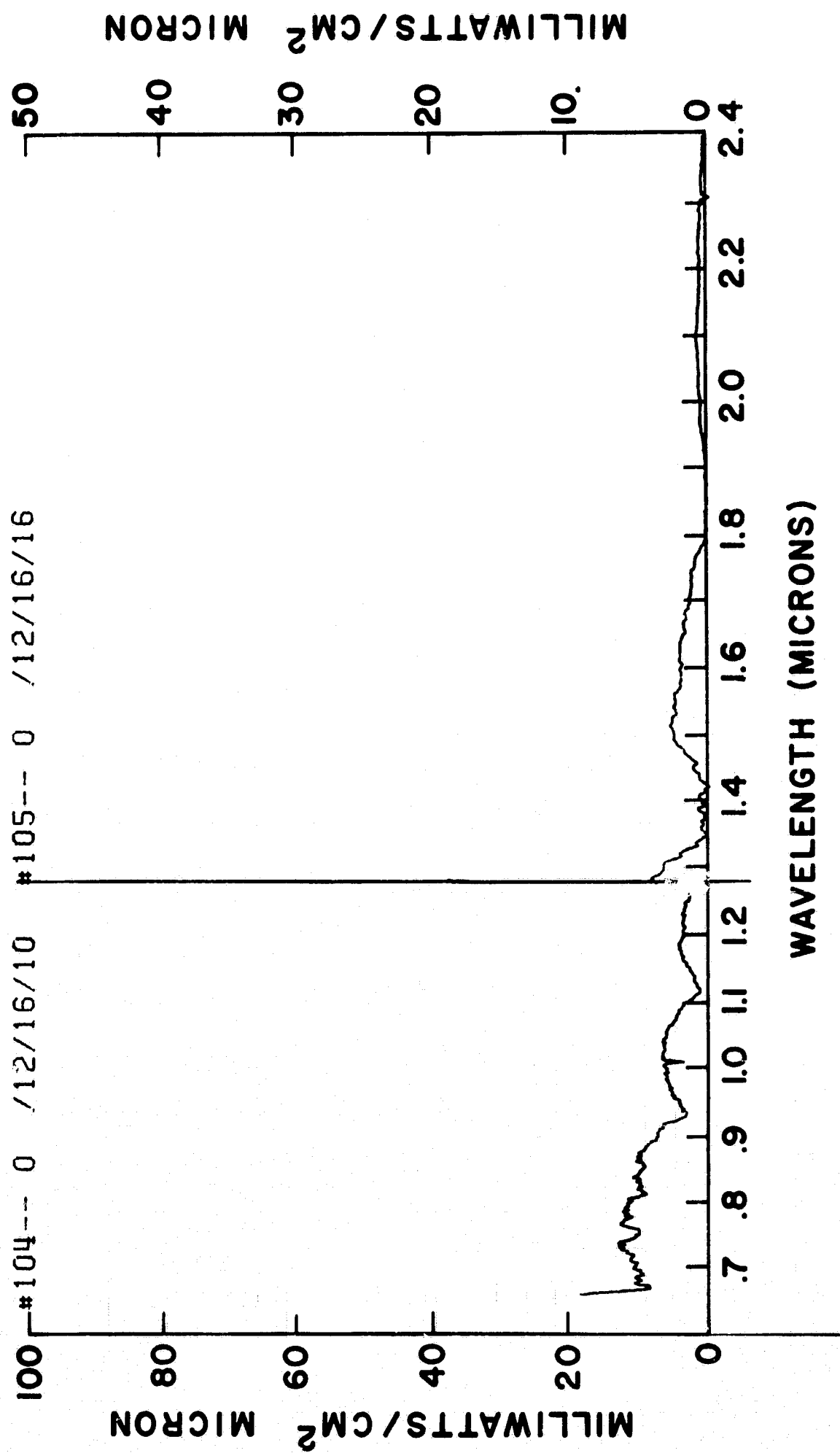


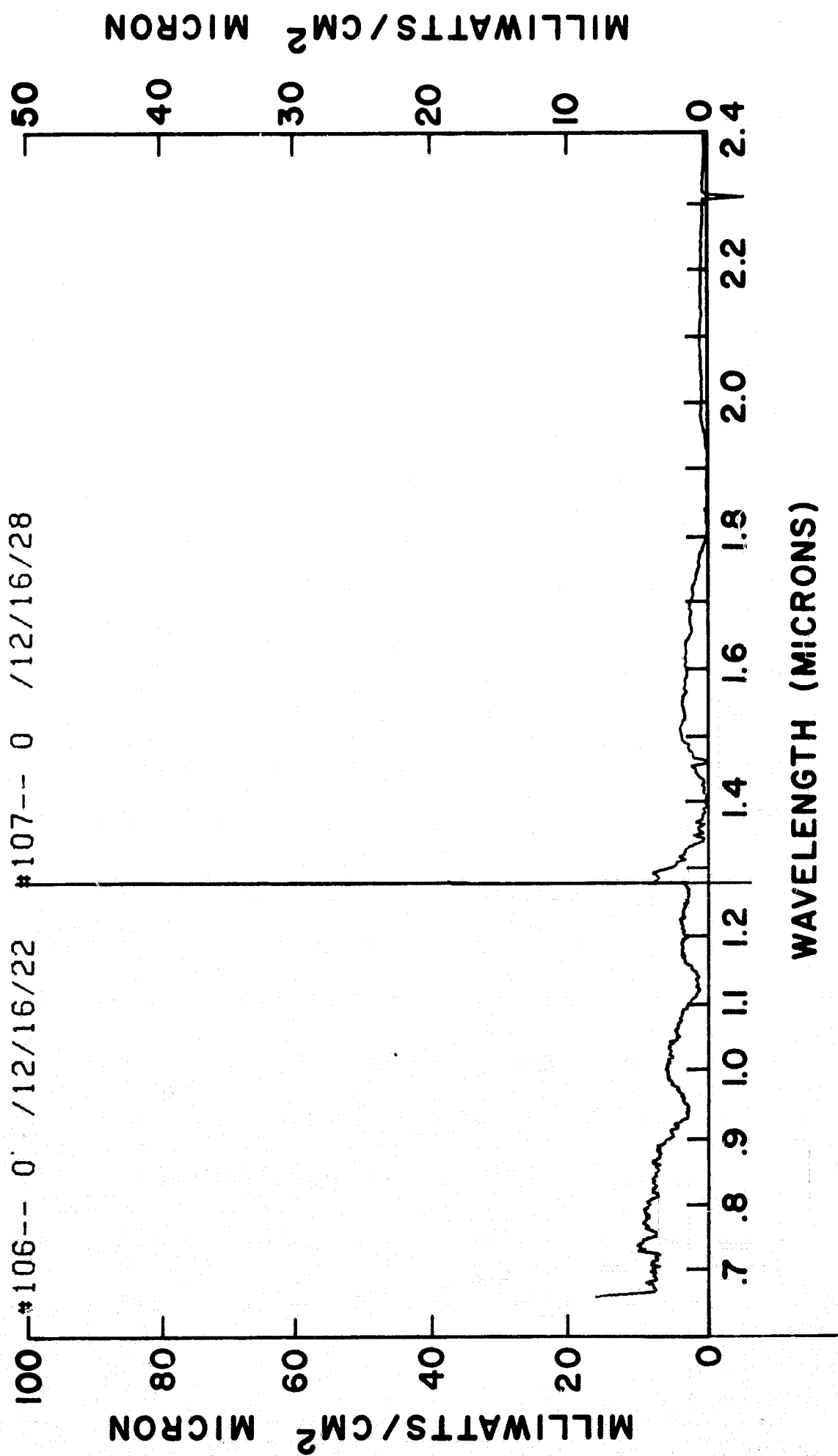


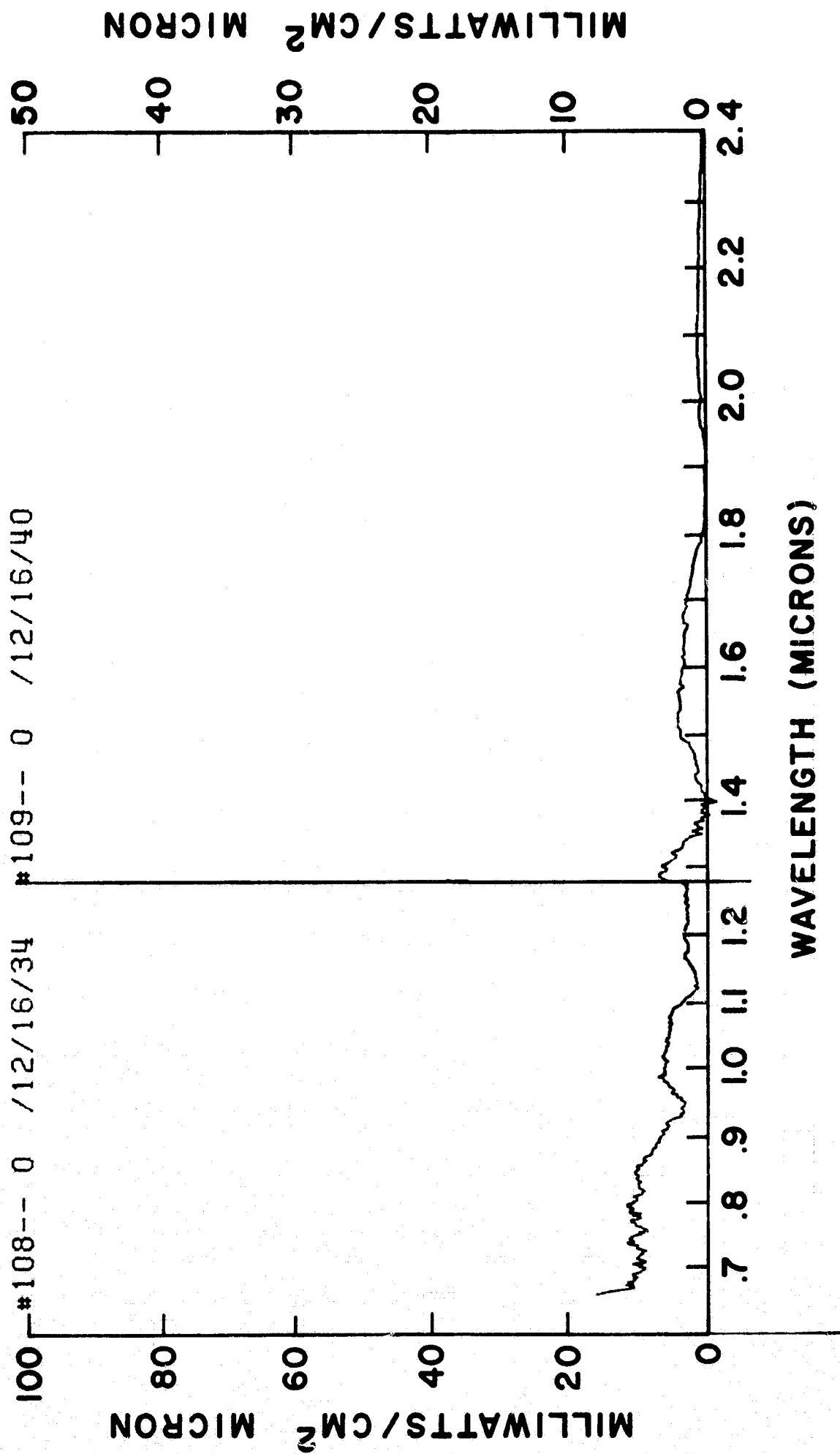


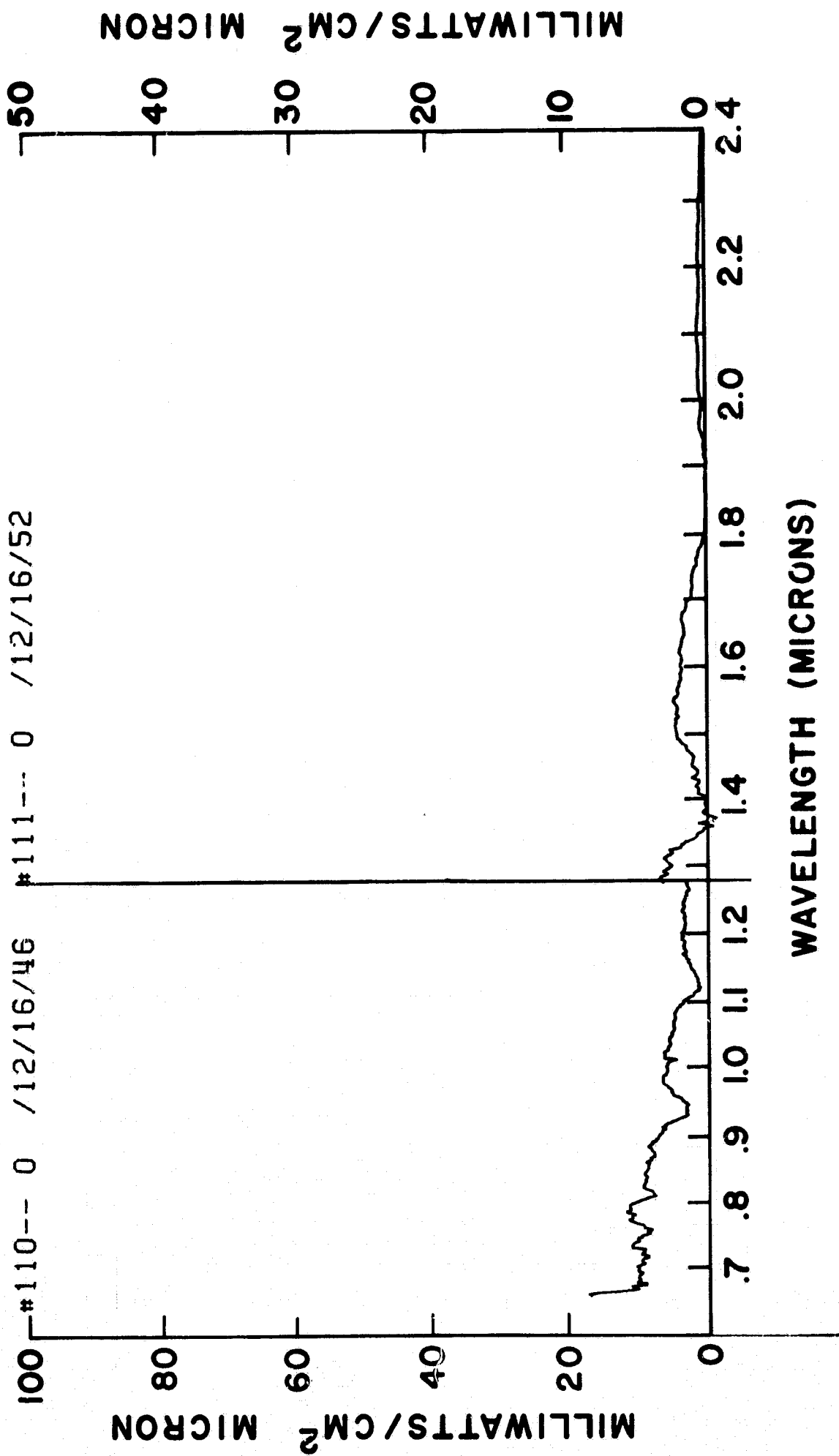


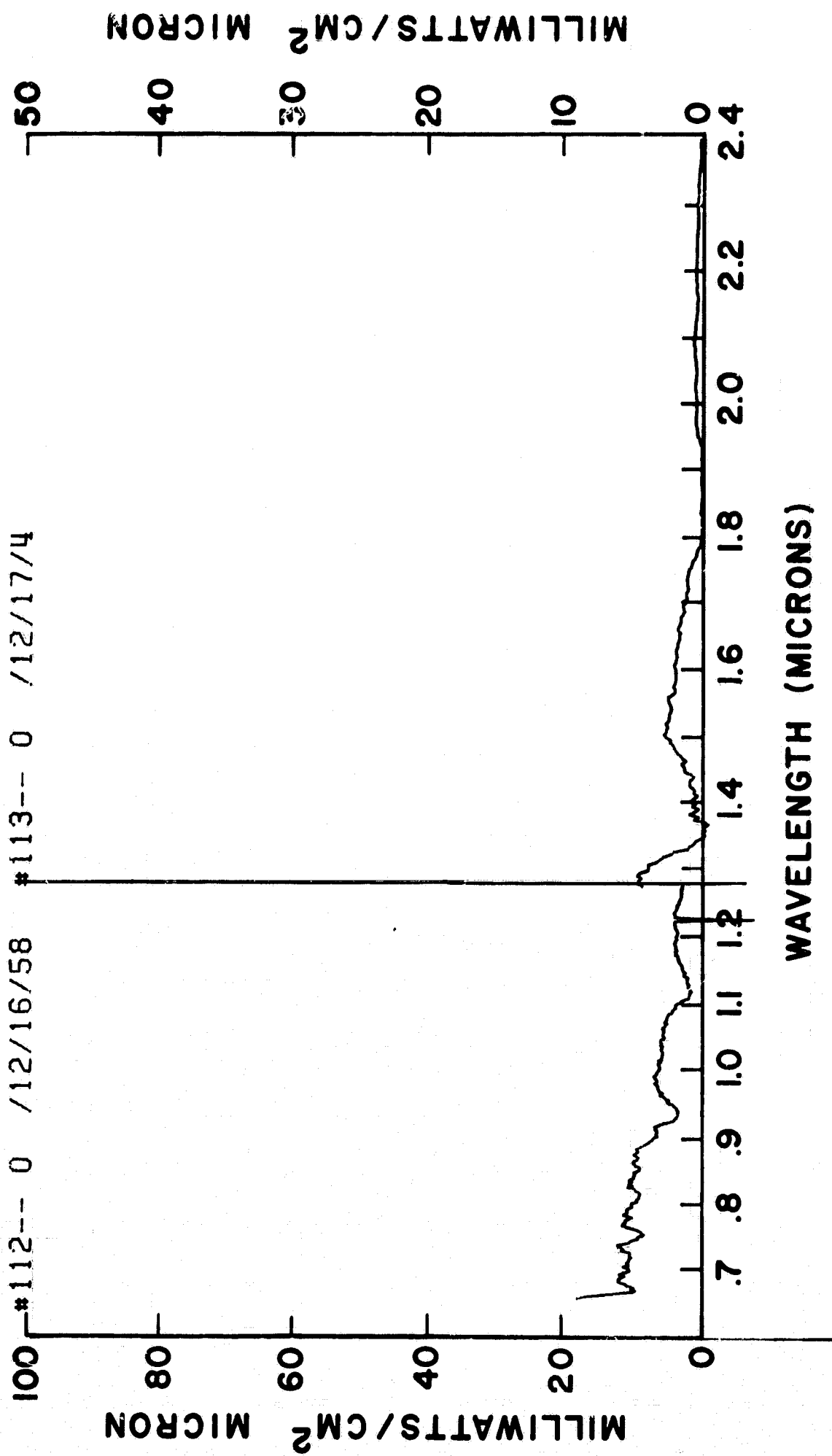


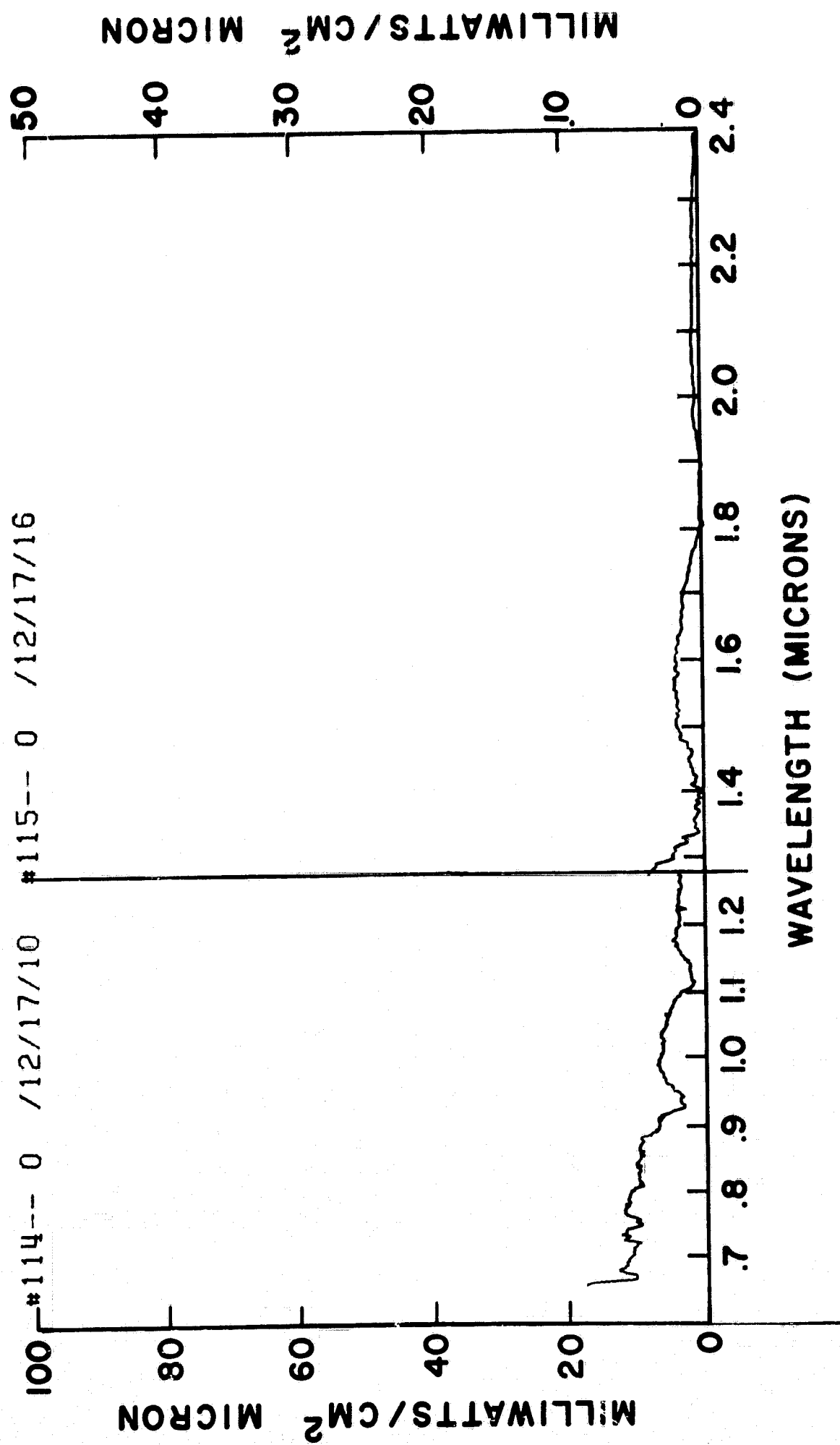












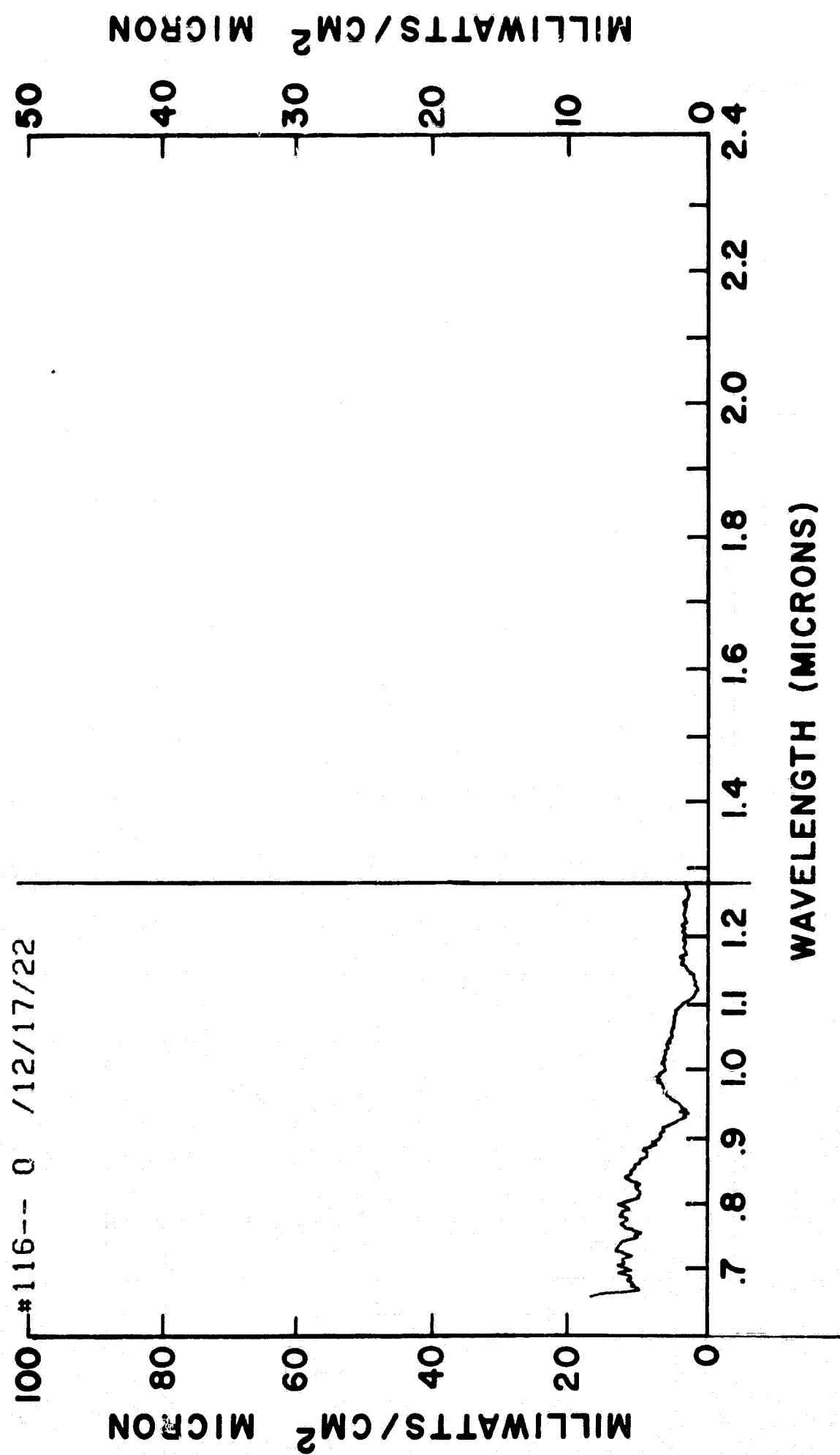


Table 3

May 27, 1968

Spectrum Nos. Inclusive	Target	Location	Altitude kft
1-4	Approach to Field #1	S border Pepper Canal 1.3 miles E Rt 115	1
5-14	Over Field #1		1
15-16	Approach Field #1		1
17-25	Over Field #1		1
26-29	Approach Field #2	S border Moss Lateral	1
30-36	Over Field #2	1.2 miles E Rt 115	1
38-44	Over Field #2		1
46-51	Over Field #3	W of Stratford, Calif.	1
	Cotton	bordering Kings River	

